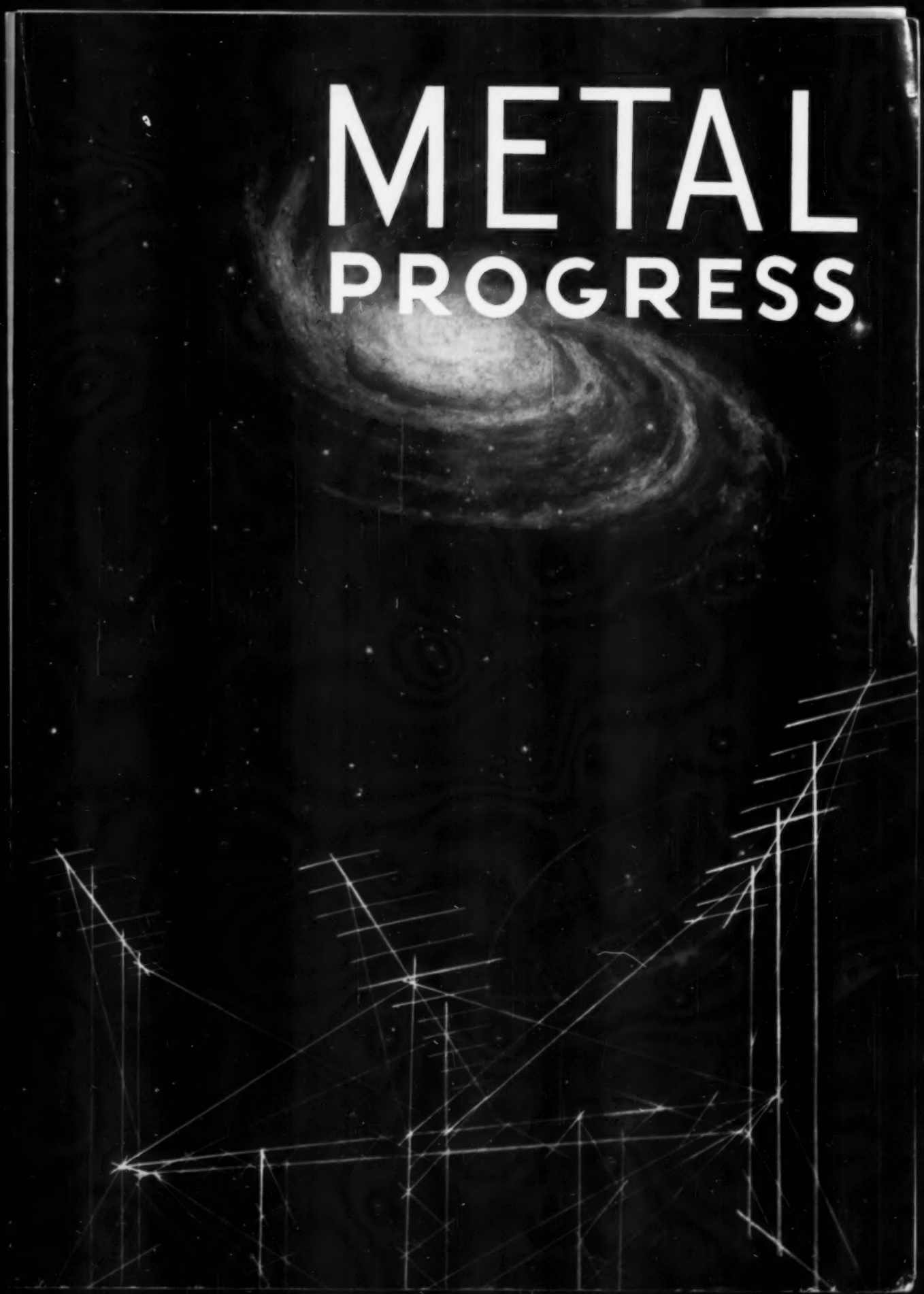
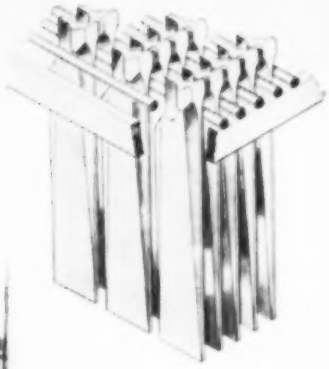
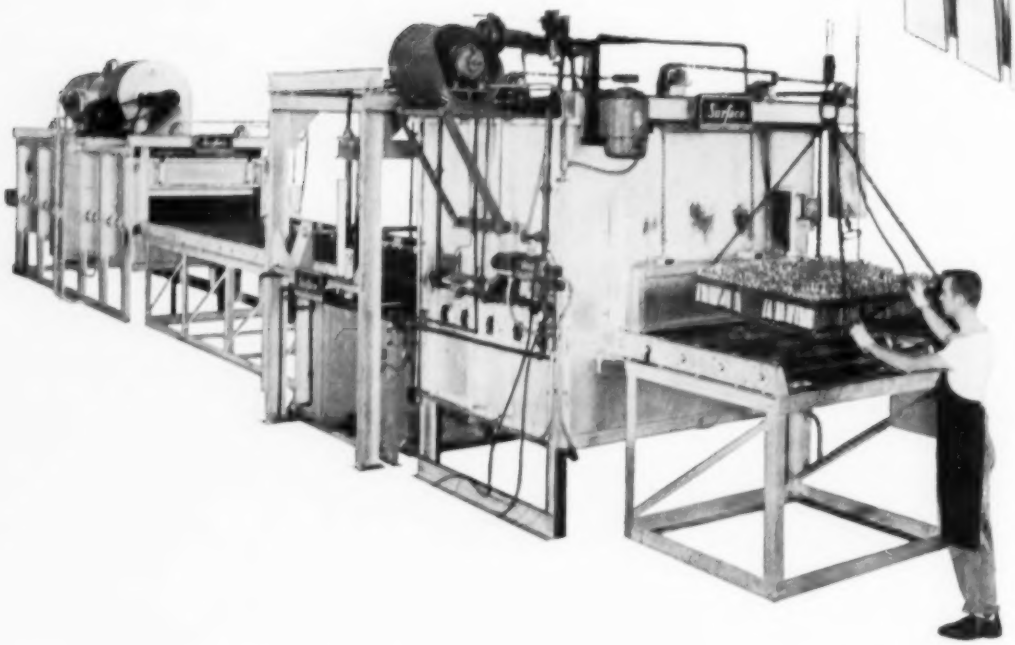
METAL PROGRESS





The fixturing—250 aluminum parts/sq. ft.—for high production heat treatment of 14S aluminum.

Operating cycle: (1) heat to 940°F in 1¼ hrs., (2) soak ½ hr., (3) fast quench, (4) run-out, (5) heat to 340°F in 1 hr., (6) soak at 340°F for 9 hrs., (7) unload.



Thousands of aluminum parts a day...

are solution heat treated and aged in this 'Surface' continuous furnace line at the Martin Parry Corporation, Toledo. High production (1875 lbs. net every 10 hours) is achieved by a high rate of heat transfer, ingenious fixturing which assures thousands of evenly-heated parts per load, and mechanized work-handling. Uniform mechanical properties in the finished 14S parts result from uniform temperatures throughout each load.

The solution heat treating furnace is heated by three radiant tubes which isolate the products of combustion from the work. A high-speed fan provides efficient forced convection heating. After a fast water quench, the work enters the aging furnace, which has a direct-fired air heater, and a blower. No special atmosphere is required in either furnace. Capacities and cycle times of the two furnaces are balanced to provide smooth, continuous production.

This modern line is only one out of hundreds of installations built by 'Surface' for *heat processing light metals*—from ingot to finished product.

Send for bulletin SC-171. Surface Combustion Corporation, 2377 Dorr Street, Toledo 1, Ohio.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION. TOLEDO 1, OHIO
Also makers of Janitrol® automatic space heating and Kathabar® humidity conditioning units

Metal Progress

Volume 69, No. 5

May 1956

Cover by LEROY FLINT, Curator at Akron Art Museum; based on astronomical equipment for studying long-wave radiation from interstellar space.

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METAL PROGRESS is published monthly by the AMERICAN SOCIETY FOR METALS. Publication office, Mt. Morris, Ill. Editorial, executive and advertising offices, 7301 Euclid Ave., Cleveland 3, Ohio. Subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50; special issues $3.00 . . . The A.S.M. is not responsible for statements or opinions in this publication.

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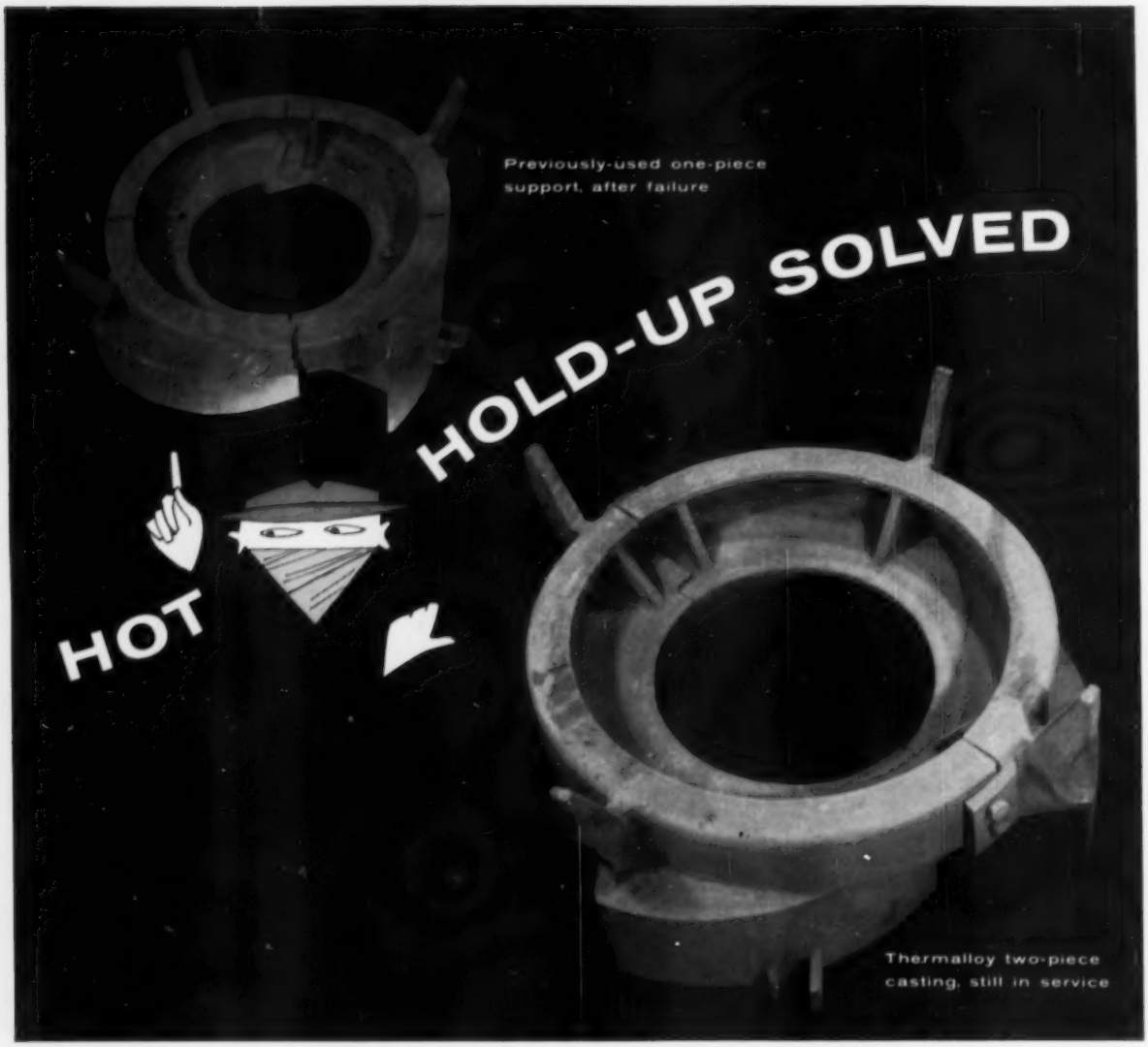


Thermalloy* outlasts previous part 4 to 1

. . . and still going strong. This "hold-up" is not as flashy as the bank or jewelry store variety. But, at one time, it was just as costly to the Diamond Chain Company . . . in lost production time.

The parts shown in the illustration were used to protect the fan in a popular, pit-type carburizing furnace. This fan was originally protected by a one-piece work support (shown above at left) which held a heavy parts-basket. This support proved unsatisfactory . . . often cracking after only 1000 to 1500 hours of use. Repairing the work support gave 1500 to 2000 hours of additional service, but required costly down time.

Diamond Chain proposed using a two-piece work support . . . which was designed by Electro-Alloys in co-operation with the manufacturer. The results—*four times* the service life of the one-piece support—and the Thermalloy casting is *still going strong!*

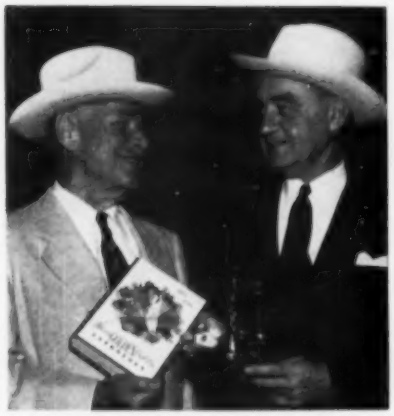
Let us show you how our engineering skill and design experience on furnace and heat-treat parts can save *you* money! Contact your local Electro-Alloys representative or write Electro-Alloys Division, 7002 Taylor Street, Elyria, Ohio. *Reg. U. S. Pat. Off.

Heat-Resistant Castings • Trays • Muffles • Conveyor Belts • Retorts • Radiant Tubes

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

As I was saying...



Bill and Ad With Canadian Trophies

OR SHOULD I say, we were yelping, "Yippee! Hi, Ho, Whittee! Whoa, Wow, Woe!" The Mayor of Calgary had braved the 15-below weather to attend National Officers' Night of the recently formed Alberta Chapter to present white Stetson cowboy hats to President Schaefer and your Secretary to remind one and all of the Great Stampede held annually in their city. I immediately entered the President in the bulldogging and bronco-riding events in their next rodeo, and guaranteed he would remain on the bronc for 12 sec. rather than the required ten.

Ad and I were so pleased and honored with the hats that we kept them on all during the evening, afraid to take them off for fear the nice things they were saying about us might make it impossible to put them back on. It was the first time in my 39 years' experience in presenting presidents to the chapters that one gave the technical talk with his hat on.

Calgary was the first stop on the tour of the western chapters, and was a portent of the many fine meetings to come. Edmonton was a revelation—temperature 22 below, frost line to a depth of 12 ft., and steel racked in the open air and no rust. It was a busy chapter, receiving its charter from President Schaefer and already enrolling 200 in the first educational course.

Thank you for reminding me to write something about the Canadian Rockies. They are grand in winter and perhaps more so in summer. There were inspiring peaks and domes and valleys, presenting an ever-changing vista, and you are always concerned whether you would run out of film.

It was raining when we landed back in Vancouver, and we were assured it was quite unusual weather (that it usually rains a dam-site harder). It was a fine meeting in the recreation building in Stanley Park, and the President performed in his usual fine style. However, both of us were thrown off stride when we observed a lady metallurgist in the audience.

If I write more briefly about the other chapters contacted on this trip (one chapter called it the "mashed potato circuit") it is not because our visits were less enjoyable, but entirely because I am limited to a two-thirds page, and 10% of these words will be blue pencilled by the Editor to make it fit. We visited with the executive committees and chapter members at Seattle (Puget Sound); Spokane (Inland Empire); Grand Coulee Dam (no chapter yet); Richland (Columbia Basin); Portland (Oregon); San Francisco (Golden Gate); San Diego; Los Angeles; Albuquerque and Los Alamos (New Mexico) — this was ladies' night and oh, what a washing the stories received! — Dallas and Ft. Worth or Fort Worth and Dallas (North Texas); Houston (Lone Star); New Orleans.

It was wonderful! Ad is a fine traveling companion (he lets me carry the grips). The ASMembers, as always, proved to be the finest group of men in the whole U. S. A. The spirit of the chapters and their fine educational programs are a real inspiration. You come back home convinced that the ASM of Tomorrow is sure to become a reality even sooner than you think.

Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Note: Only annoying feature was being side-tracked for 23½ hr. due to a 65-ft. snowslide just ahead. The Southern Pacific gave us free meals and kept the bar open. However, the usual prices prevailed and so even with free meals we lost money.

Easy to Mix. Just add water according to instructions. Mixes in about five minutes.

Consistency of Mix is as workable as any cement mix.

Pours Readily into any prefabricated form.

New ALUNDUM* 33-I insulating castable...mixes and pours like concrete...protects to 3300°F.

A New Norton Refractory Rx

Now you can protect critical areas in your furnaces and other high temperature equipment to 3300°F with ALUNDUM 33-I insulating castable — a new, easy-to-install NORTON Refractory Product.

- 33-I comes in dry form in moisture-protective bags.
- 33-I — You just add water according to instructions. Mixes readily.
- 33-I pours into any prefabricated form like a concrete mix.

And . . .

- 33-I insulates up to 3300°F.
- 33-I is light in weight and monolithic in structure.
- 33-I saves down time for repairs.

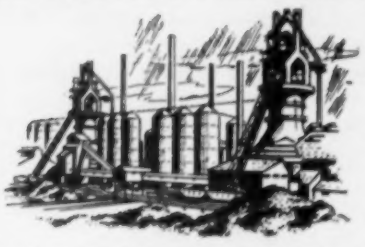
Characteristics of ALUNDUM 33-I

Density	100 lbs. per cu. ft.
Setting up time	
Stiffens	1 hr.
Initial set	4 hrs.
Final set	18-24 hrs.
Chemical Analysis — Al_2O_3	Primarily
SiO_2	< 0.1%
Fe_2O_3	< 0.1%
Maximum hot face temperature	3300°F
Water added per 100 lbs.	Approx. 4¼ gals.
Grain Size	6F

This newest Norton refractory Rx is *engineered and prescribed* for maximum protection and quick, easy installation in a wide range of uses. For further facts on ALUNDUM 33-I insulating castable, write to NORTON COMPANY, Refractories Division, 324 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Typical Applications in Metal Processing



Linings for atmosphere furnaces. Insulation for pit furnace linings.

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REFRACTORIES
Engineered... Rx ...Prescribed
Making better products...
to make your products better

MUELLER BRASS CO. improves LENSOMETER lower cost

FORGED PART APPROXIMATELY ½ SIZE

Precision and extreme accuracy are vitally important functions of the Lensometer, manufactured by the Instrument Division of the American Optical Company, Buffalo, N. Y. The Lensometer is used to determine the focal strength and axis of an optical lens and, consequently, must be extremely precise in operation to provide accuracy and uniformity in lens prescriptions.

Forgings made by the Mueller Brass Co. play an important role in the construction of the Lensometer and contribute to its outstanding performance. Formerly, the body of the Lensometer was produced from *three* sand castings, but these now have been replaced by just *two* forgings. Naturally, this simplifies assembly, and the big forged bronze main support arm, shown above, along with the lens support bracket insures the constantly accurate alignment of the instrument. During the first year when forgings were used instead of castings, American Optical not only recovered the initial tooling costs but also realized considerable savings on each Lensometer produced. This is another good example of the way Mueller Brass Co. forgings can benefit a product two ways . . . better performance and lower costs. Chances are, your product can likewise be improved at a savings to you if you specify brass, bronze or aluminum forgings made by the Mueller Brass Co.

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Riehle Universal Testing Machines — whether hydraulic or mechanical — can be equipped with the most modern and flexible autographic strain measuring instrumentation. The Riehle-built Recorder is located under the writing table of the Indicating Unit with its controls placed conveniently on the console. A complete family of recorder accessories is available — comprising various types of strain measuring instruments for magnification ratios up to 1000:1, strain rate indicator and time interval marker. Mail coupon for further information.

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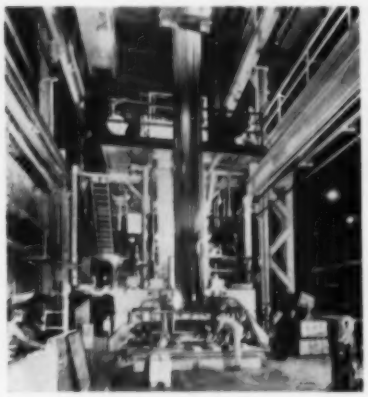
APPLICATION and EQUIPMENT new products

Continuous Galvanizing

A continuous hot-dip galvanizing line with a rated capacity of 7000 to 8000 tons of galvanized sheets a month has been announced by Jones & Laughlin Steel Corp. It utilizes the Armco-Sendzimir process. The line is able to produce galvanized sheet gages from 14 to 30, in widths of 20 to 48 in. and in lengths of 60 to 168 in. The flexibility of the line permits a full range of industrial coatings. The J&L line is 610 ft. long over-all. The



oxidizing furnace is 20 ft. long, the reducing furnace 104 ft. long and the controlled cooling furnace 224 ft. long. It will operate for 13 weeks continuously before it is shut down for removal of wastes and maintenance.

For further information circle No. 1127 on literature request card, page 32-B.

X-Ray Diffraction

The XRD-5 X-ray diffraction instrument which permits rapid accurate analysis by the use of a high-speed proportional counter and preamplifier has been announced by the X-Ray Dept. of General Electric Co. The proportional counter has a life span that is 1000 times longer than that of the conventional Geiger counter. The single-crystal orienting device makes it possible to routinely identify unknown organic or inorganic single crystals of matter and permits scientists to analyze fibers and wires and

study preferred orientations by the reflection method. The helium tunnel assembly, which greatly extends the range of application for fluorescent analysis, increases sensitivity and permits routine accurate quantitative analysis of such elements as sulphur, chlorine, potassium and calcium.

For further information circle No. 1128 on literature request card, page 32-B.

Castable Refractory

A new high-temperature insulating castable has been announced by Norton Co. It is effective in providing insulation against temperatures up to 3300° F. Suggested applications include back-up insulation for kilns and furnaces, back-up for pit furnace linings, high-temperature burner port, insulation for chemical furnaces, and any other application where high-temperature insulation is a must. Alundum 33-I is light weight and monolithic in structure having an

aluminum oxide content of about 96%. The new castable is easy to use. One bag of 100 lb. when mixed and poured forms just 1 cu. ft. of cast refractory.

For further information circle No. 1129 on literature request card, page 32-B.

Induction Hardening

A new line of high frequency induction hardening machines has been announced by the Process Machinery Div. of Cincinnati Milling Machine Co. They consist of three units—a power supply, an oscillator and a work unit. Work and oscillator units can be placed directly in a production line,

and if desired, the power supply unit can be located several hundred feet away. The new machine is rated at 30 kw. and has a frequency range of 1200 to 1400 kilocycles. This permits rapid surface hardening of parts requiring shallow case depth and very narrow transition zones between case and core, as well as for any small or thin walled parts. The accompanying illustration shows the work unit set up for hardening hollow thin-walled turbine shafts.

For further information circle No. 1130 on literature request card, page 32-B.

Metal Analysis

A new portable electronic instrument for checking metals without laboratory analysis has been announced by Brush Electronics Co. It

YOU'RE SURE OF CLEAN, BRIGHT PARTS WHEN YOU USE SUN QUENCHING OIL 11

The success of your bright quench depends largely on the oil you use. Partial breakdown of an oil in service results in dirty parts. Many times, even a new oil causes failures by staining parts.

High-quality Sun Quenching Oil 11* will give you clean, bright parts from the time you put it in your tank. And, because of high thermal stability, Sun Quenching Oil 11 will continue to give you clean bright parts for long periods.

Most economical because of its low initial cost and long life, Sun Quenching Oil 11 gives uniform quenching in any system. A high flash point eliminates fire hazards.

For complete technical information on how Sun Quenching Oil 11 can assure you of clean, bright parts, see your Sun representative or write for free Technical Bulletin 29.

FREE TECHNICAL BULLETINS

The following free technical bulletins on Sun Quenching Oils are available: Sun Quenching Oil 11 (Bulletin 29); Sun Quenching Oil Light (Bulletin 37); Sunquench 78 (Bulletin 45). Also, pamphlet entitled, "Sun Quenching Oils."

Write to SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-5.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

PHILADELPHIA 3, PA.

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SUNOCO®

*TRADE-MARK

can identify ferrous and nonferrous metals by comparative testing with known samples and can be used to sort mixed metals of unknown character into homogeneous groups for further testing. It can also be used to check for hardness, heat treatment, metallurgical structure, uniformity,

plating thickness and plating adhesion. Operation of the device is based on a principle of the thermocouple effect: the junction of two dissimilar metals produces an electromotive force. The illustration shows the use of the Metal Monitor for checking heat treatment.

For further information circle No. 1131 on literature request card, page 32-B.

Hardness Tester

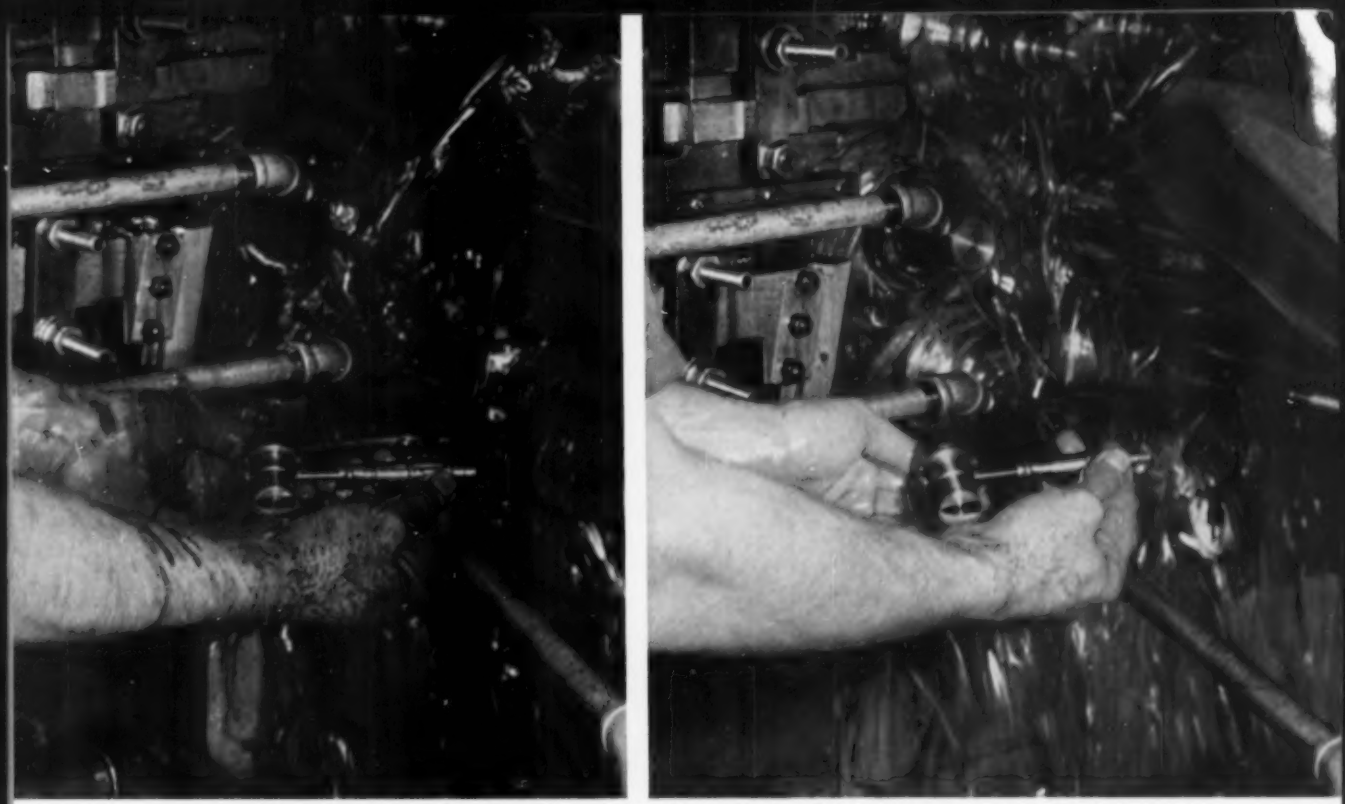
Company for Technical Progress has announced the availability of a hardness tester which has been manufactured in West Germany and used throughout Europe. It is a light weight

portable tester with applications in metalworking, automotive, aviation, tubing and other manufacturing fields. Oppel covers the five most widely used hardness scales, supplying laboratory accuracy plus easy handling.

For further information circle No. 1132 on literature request card, page 32-B.

Tumbling Barrels

A series of heavy-duty barrels for precision finishing of large-quantity loads weighing from 700 to 3800 lb. has been announced by Lord Chemical Corp. The line includes six octagonal barrels, one and two compartments, ranging in total capacity from 6.9 to 36.6 cu. ft. Barrel diameters are 30 and 36 in.; barrel lengths from 16 in.



Black cutting oil (left) makes close control difficult. Operators dislike dirty operating conditions it creates. Close control is easier and workers are happier with transparent Sunicut cutting oil (right).

WHY USE A BLACK CUTTING OIL WHEN YOU DON'T NEED IT?

Sunicut oils give you better visibility without sacrificing machining efficiency.

When trying to maintain close control over machines producing precision parts, operators can be handicapped by "black-oil blindness". It is hard to see the tools, the workpiece, and the finishes. Checking close tolerances is difficult when the graduations on micrometers and gauges are obscured.

Worse still, as the operator sees it, are the dirty working conditions caused by dark oils. His clothes get saturated with hard-to-remove stains, and his hands are black from one end of the shift to the other.

Transparent Sunicut oils help keep your operators happy and will make close control easier ...and transparent Sunicut oils will do the job with no sacrifice in machining speed or finishes.

To get the full story on Sunicut oils, see your local Sun representative, or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. I-41.

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For any machining or grinding operation...

THERE'S A SUN OIL THAT'LL GIVE YOU HIGH EFFICIENCY AND LOW OVER-ALL COST

No two machine shops have exactly the same problems when it comes to selecting cutting oils...even when they're running the same job. And, until somebody comes up with the truly universal cutting oil, you can't afford to disregard the importance of oil selection. Here's how Sun can help you.

First, Sun makes a complete line of emulsifying and straight cutting and grinding oils. Second, your Sun representative, backed up by field engineers, has the necessary practical experience to recommend the oil that will give you both high machining efficiency and low over-all costs.

For the full story about Sun's cutting oils, see your Sun representative...or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. I-42.

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Forged-in pockets provide tougher, stronger dies

This 35,000-pound die block, made of Finkl FX-T3 steel, has a forged-in pocket 12"x29"x34". In addition to the improved physical properties, the pocket forging increases the saving in machining time. There are many ways, such as this, that Finkl engineers can help you when planning die block or forging requirements.

When you next consider hot work tooling, die blocks or forgings, consider Finkl for the best. The quality of Finkl Hot Work Die Steels is the finest available and costs you less in the long run. Finkl die blocks will make a lasting impression with "impressions that last." Our engineers will gladly offer the advantage of their knowledge and our experience. There is no obligation.

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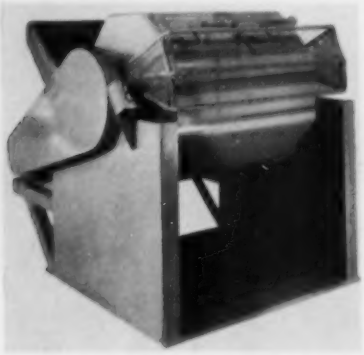


to 5 ft. The oversize motor drive is powered by a NEMA-type motor of 1½ to 7½ hp. Controls include forward, reverse, off and jog switches, arranged in a watertight mounting. A 24-hr. timer is available as optional equipment. Drum can be removed from the frame, and the drum height is arranged for easy inspection of the drum in any position. The reversing across-the-line starter is protected against overload.

For further information circle No. 1133 on literature request card, page 32-B.

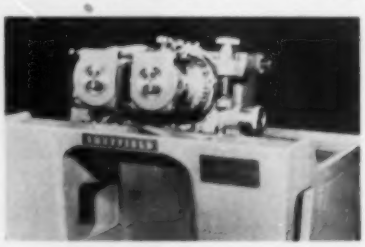
Arc Welding Machines

Three new arc welding machines, a d.c. rectifier, an a.c./d.c. rectifier for metallic arc welding and an a.c./d.c. Heliwelder for inert-gas and metallic arc welding, have been announced by Air Reduction. The d.c. arc welder has improved selenium rectifiers for converting alternating current to direct current. It features a single range of current adjustment. The a.c./d.c. rectifier will supply either type of current. Patented control circuit eliminates need for any mechanical-type control and selenium rectifiers are specifically designed for welding duty. As in the d.c. rectifier, this is available in 200, 300 and 400 amp. models. The Heliwelder is available in 200 and 300 amp. models. It consists of a single-phase transformer, selenium rectifier and stabilizing reactor, permitting the operator to select either a.c. or d.c. welding current. High frequency, with a rheostat control, is built-in and balancing resistor in series with transformer secondary provides correct current for inert-gas welding.

For further information circle No. 1134 on literature request card, page 32-B.

Thread Rolling Machine

A new circular roll threading machine for high production thread rolling of studs and machine screws has been announced by the Sheffield Corp. It will produce up to 5200 parts per hour, ranging in thread size from ⅛ to ¾ in. o.d. by 2 in. long. Rolling is performed by two interchangeable and reversible precision ground rolls rotating at different speeds and mounted on heavy duty roller bearing



spindles. Parts are fed tangentially between the rolls by a revolving work feeder ring, falling free after rolling down a chute to a container. The feeder ring can be magazine loaded manually or automatically.

For further information circle No. 1135 on literature request card, page 32-B.

Chromium Plating

Chrome Electro-Forming Co. has announced custom made units for precision hard chromium plating. The process permits deposition at the rate of 0.000001 in. per min. Close tolerances required by parts which demand extreme accuracy, such as gages, are

held to within 0.0001 in. It can plate in grooves, recesses and shoulders and maintain sharp, clean corners, necessary for thread gages, taps and drills. Close control over time, current density and solution temperature are pro-

vided to guarantee satisfactory and uniform performance. The equipment for every unit is integrated, with tank size, power, location of anodes and all other components properly related.

For further information circle No. 1136 on literature request card, page 32-B.

Flux Pot

Helmco, Inc., has announced a new unit for warming and controlling brazing and soldering flux. It prevents underheating with inefficient, too-thick flux and overheating with corresponding dry-out, evaporation and out-of-emulsion flux. The Helmco-Lacy flux pots are manufactured in two sizes, holding 5 and slightly over 10 lb. of flux. Exteriors are of satin-finish aluminum. Highly glazed vitreous enamel bowls prevent contamination of the flux. Heating elements are completely insulated to insure perfect operation and a dial thermostat allows temperature setting adjustments and control.

For further information circle No. 1137 on literature request card, page 32-B.

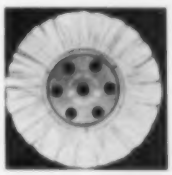
Welding Nickel-Iron-Chromium Alloy

A new electrode and filler wire and rod for welding 40% nickel, 21% chromium, 3% molybdenum and 31% iron alloy has been announced by the International Nickel Co. Both products give X-ray quality welds and allow operation in all positions. The welds have corrosion resistance and strength equal to that of the base metal itself. Made in four convenient diameters, 3/32, ⅛, 5/32 and 3/16 in. the 135 Ni-o-nel electrodes come in 14-in. lengths. The 65 Ni-o-nel filler wire is produced in diameters of 0.035, 0.045 and 0.062 in. on disposable spools for inert gas welding consumable process. It is produced in 36-in. straightened and cut lengths for tungsten-arc process and is available in 5 diameters.

For further information circle No. 1138 on literature request card, page 32-B.

Buffs

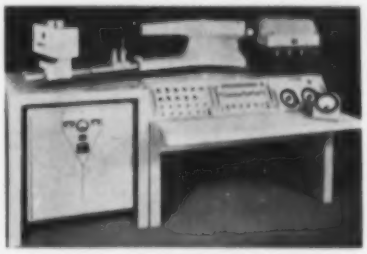
Hanson-Van Winkle-Munning has announced new steel centers for its buffs to make the metal finishing wheels capable of dissipating fractional heat fast enough to keep the buff cool under all practical operating conditions. The new center, composed of two steel discs, also provides stronger support for the buffs. The buffs are available either Binderized, impregnated with the same compound that is used for cutting or untreated. They come with 3, 5, 7, or 9 in. inside diameters with outside diameters as needed.



For further information circle No. 1139 on literature request card, page 32-B.

Direct Reading Spectrometer

A new direct reading medium quartz spectrometer has been announced by Jarrell-Ash Co. The new instrument



will perform analyses for up to 11 constituents in 2 min. or less with results indicated on a meter or a recorder. The direct reader has been designed so that the accuracy is limited only by factors inherent in the excitation conditions or in the sample. The ratio of the intensities at two wave lengths in a steady, controlled source can be determined

with a coefficient of variation of about 0.25%.

For further information circle No. 1140 on literature request card, page 32-B.

Portable Hardness Testers

A portable metal hardness tester that provides direct readings corresponding to Rockwell A, B or C scales or Brinell medium or low scales has been announced by Newage International, Inc. A direct reading can be made by placing the tester on the metal, pressing the handgrips down

and reading the dial. Each instrument is individually calibrated to ±1.5 points Rockwell and 5 points Brinell. The tester is used on a wide range of metal parts or products, thick or thin sections, flats or rounds. All instruments are furnished complete with diamond penetrator and one test block. For continuous-run testing, a bench adapter is available.

For further information circle No. 1141 on literature request card, page 32-B.

Forging Heater

An application of gradiation heating principles to fast heating for high-production forging has been announced by the Selas Corp. of America. A gas-fired machine heats ¾ in. diam.

by 1 in. long stainless steel slugs to forging temperature of 2100° F. delivering one every 5 sec. The equipment is completely self-contained with all necessary combustion, handling and temperature controls.

For further information circle No. 1142 on literature request card, page 32-B.

Etching

A new electric pen that will etch ferrous and nonferrous metals has been announced by Newage International. Through a magnetic vibrating

system a short continuous arc is produced, thus enabling the user to etch the hardest tempered steel, Monel, brass, copper, aluminum, tungsten, carbide, gold and silver. The markings can be removed by grinding, filing or destroying the article.

For further information circle No. 1143 on literature request card, page 32-B.

Potentiometer-Recorder

Wheelco Instruments Div., has announced its new Series 8000 electronic potentiometer-recorder of the null-balancing type. It is available in a wide range of models which measure, indicate, control, and give a permanent record of such variables as temperature, speed, strain, hydrogen ion (pH) and other quantities that can be resolved into electrical signals.

For further information circle No. 1144 on literature request card, page 32-B.

Centrifugal Fans

New design in centrifugal fans giving them efficiency and low noise levels has been announced by Chicago Blower Corp. A wide range of wheel diameters is available in both Type B, backward curved fans, and Type F, forward curved fans. They can handle hot air and gases up to 600° F. and may be used in drying ovens, driers and other industrial process applications. Housings are of continuous-weld heavy plate steel construction. All motor and bearing bases are

with TOCCO* Induction Heating

Progressive engineers at Clark Equipment Company's Axle Division recently adopted TOCCO Induction Heating for hardening the inner wheel bearing seats of their axle housings. TOCCO*-hardening is strictly a "quality specification"—part of Clark's never-ending program of product improvement.

Look At These Results! After testing various methods of surface treatment including flame hardening and shot peening, TOCCO induction hardening was selected because the average improvement in fatigue life was greater than with any other type of surface treatment. The improvement in fatigue life with TOCCO equipment is approximately 400%.

In addition to improved fatigue life, surface wear resistance and improved grindability are achieved.

Fatigue test consisted of loading axle housing on spring seats to approximately twice the rated load and stroking at 180 cycles per minute.

Hardening Process	Per cent Improvement In Fatigue Life Over Standard Production
Shot Peening	50%
Flame Hardening	300%
TOCCO Induction Hardening	400%

In your search for ways to improve your product to meet today's tightening competition, don't overlook TOCCO as a sound means of improving product quality, increasing production speed and lowering production costs.

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formed from a heavy gage solid steel plate, broken and punched and then welded at the corners.

For further information circle No. 1145 on literature request card, page 32-B.

Laboratory and Production Ovens

Despatch Oven Co. has announced its new line of V series laboratory and production ovens in three temperature ranges, 100 to 500° F., 250 to 650° F. and 450 to 850° F. Laboratory ovens are equipped with air convection systems that assure a constant heat without temperature variation or stratification. Temperature uniformity has been improved because of the interconnecting plenum chambers above and below the heater. Incoming air is

preheated and mixed with heated air in the air plenum before it begins its horizontal flow through the oven's working chamber. New controls and the "Whirlblast" convection system assure even heat throughout the working chamber in production ovens, too. Oven bodies have been engineered to allow for fast loading and unloading and maximum heat recovery.

For further information circle No. 1146 on literature request card, page 32-B.

FORD MOTOR COMPANY Paints a Rainbow...

A technique in spraying developed by the Ford Motor Company results in exciting rainbow pastels . . . plus new speed in paint application . . . faster color changeover . . . and superb quality of finish.

DESPATCH built and installed the Down Draft Spray Booth shown above in Ford's Dearborn plant. Wealth of production experience assures the highest standard of performance from DESPATCH equipment. There's a DESPATCH-trained resident engineer near you. Why not talk to him about your finishing requirements?

Photo of interior of DESPATCH spray booth shows down draft air flow. Notice the wide working area around the production line.

Write for NEW Bulletin 51

Just off the presses! . . . 16 colorful pages of suggestions, tips and ideas on modern ways to achieve better finishes, faster production and smoother handling of metal products . . . at lower cost.

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PIONEERS IN ENGINEERING FINISHING SYSTEMS FOR INDUSTRY

APPLICATION and EQUIPMENT new literature

1148. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Inst.*

1149. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1150. Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

1151. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

1152. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1153. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

1154. Aluminum Alloys
Book on analysis of aluminum, brass, bronze alloy specifications. *Sonken-Galamba Corp.*

1155. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1156. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

1157. Aluminum Extrusions
Data on commercial aluminum extrusions. *Superior Industries*

1158. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". *International Nickel*

1159. Arc Welding
Folder on carbon and low alloy steel wire for submerged arc welding. *Metal & Thermit*

1160. Atmosphere Cooling
Bulletin T-40 on automatic heat treating units with controlled atmosphere cooling. *Ipsen Industries*

1161. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1162. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1163. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

1164. Atmospheres
Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

1165. Basic Steelmaking
12-page bulletin on how to make basic electric steel. References. *Basic Refractories*

1166. Bearings
20 data sheets give special properties and case histories for new Rulon oil-free bearing material. *Dixon Corp.*

1167. Beryllium Copper
New 4-page folder on beryllium copper for molds and dies for plastics, forging dies, forming and drawing dies and dies for zinc die castings. *Beryllium Corp.*

1168. Beryllium Copper Strip
New 12-page Bulletin 6 on available alloys, tempers, sizes and tolerances. *Penn Precision Products*

1169. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1170. Blackening Copper
Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

1171. Blast Cleaning
8-page bulletin 1403 on liquid blast cleaning equipment. Drawings of cabinets. *Pangborn Corp.*

1172. Bolts
16-page booklet on high-strength bolting for structural joints includes ASTM specifications covering this bolting material. *Bethlehem Steel*

1173. Brazing
16-page pocket-sized guide to selective fluxing for low temperature silver brazing. *American Platinum*

1174. Brazing Alloys
Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

1175. Brinell Machine
Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

1176. Calibrating Machine
Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

1177. Carbon Control
Bulletin SC-168 on system for automatically controlling carbon potential in continuous and batch furnaces. *Surface Combustion Corp.*

1178. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1179. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

1180. Castings
New 16-page booklet, "Cast to Outlast Destructive Service", gives latest information and case histories on use of sand, centrifugal and precision investment castings. *International Nickel Co.*

1181. Ceramic Tools
10-page report on machining steel with ceramic tools includes grinding ceramic tools, new-type tool holder, geometry of ceramic tools. *Norton*

1182. Chromate Finishing
Data file on proseal products for conversion coatings on cadmium, aluminum, zinc. *Swift Industrial Chemical*

1147. Cemented Carbides
66-page metalworking catalog contains specification information on standard brazed carbide tools, tool holders, standard carbide throw away inserts,

blanks for twist drills, bushings, guide rings, balls and valve seats. It also includes data on most effective cutting speeds for carbide tools, machine tool horsepower requirements, carbide tool geometries and carbide grade selection. The new machinability computer is also described. *Carboloy Dept., General Electric Co.*

1183. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

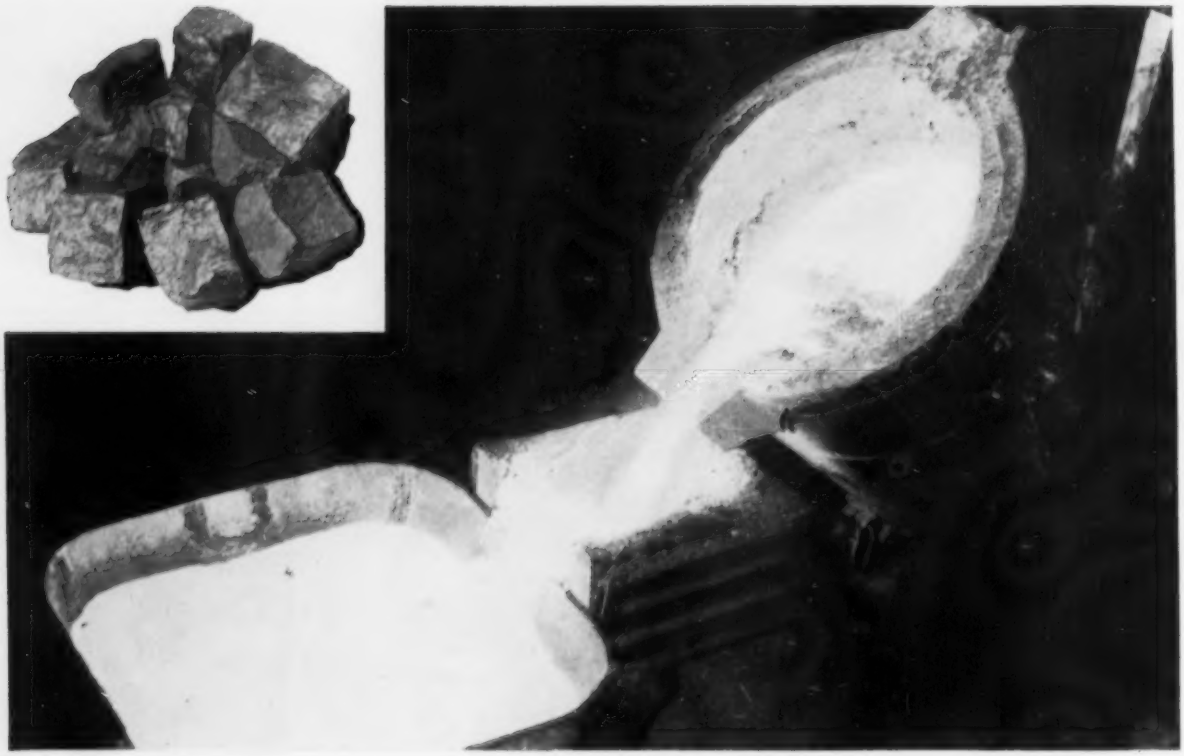
1184. Chromium Stainless
12-page book on fabrication and use of type 430 stainless steel. *Sharon Steel*

1185. Cleaner
Bulletin on solvent detergent for power washers that cleans and protects against rust. *Oakite Products*

1186. Cleaners
Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

1187. Cleaners
New 4-page bulletin on cleaners for preparing metallic surfaces for electroplating, anodizing, painting. *Hanson-Van Winkle-Munning*

1188. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning", discusses



Pouring ferroalloys at Globe Metallurgical Corporation, Beverly, Ohio. Inset: Ferrosilicons are made from high quality raw materials, assuring a clean metal free from segregation and inclusions.

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tank, barrel and machine cleaning, pickling, zinc phosphate coating, rust prevention and other processes. *Oakite*

1189. Cleaning Compounds
Data sheets on heat treating, plating and finishing compounds; rust inhibiting and quenching oils. *Swift Industrial Chemical*

1190. Cold Finished Steel
16-page booklet on 10 grades of cold finished steels. Analysis, machinability, heat treatment, wear resistance. *Jones & Laughlin*

1191. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1192. Comparator
Bulletin on electric comparator for external measurements of parts from gage blocks to production parts. *Metron Instrument Co.*

1193. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1194. Continuous Casting
24-page book, "Better by the Mile", describes how the Rossi continuous casting machine works. History of continuous casting. *Scovill Mfg.*

1195. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

1196. Controllers
80-page catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

1197. Controllers
12-page booklet on temperature controls and special purpose controllers. Operation, design, installation. *Assembly Products, Inc.*

1198. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1199. Copper Alloys
24-page manual on alloys in rod form. Typical parts. Specifications covering alloys described. *Mueller Brass*

1200. Corrosion Resistance
20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampco*

1201. Corrosion Resistant Alloy
20-page booklet on nickel, chromium, molybdenum, iron alloy gives chemical composition, corrosion data, properties and welding characteristics. *Haynes Stellite*

1202. Creep Testing
Bulletin RR-13-54 on new creep testing machine. *Riehle*

1203. Cutting Machine
Folder on universal power cutter for plate and sheet metal working. *Nord*

1204. Cutting Speeds
Wall chart shows proper cutting speeds with various surface speeds for aluminum stock in automatic screw machines. *Kaiser Aluminum*

1205. Cutting Tools
New 4-page bulletin includes physical and mechanical properties and results of a series of machining trials. *Stupakoff Div., Carborundum Co.*

1206. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

1207. Degreasing
New bulletin on OPNT vapor degreaser describes and diagrams its construction. *Circo Equipment*

1208. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1209. Diamond Polishing
8-page booklet on metallographic polishing with diamond abrasive and its advantages over silicon carbides. *Elgin National Watch Co.*

1210. Die Casting
24-page catalog describes die casting process, machines and products. Instructions on installation of die casting machines, designing and fabricating dies. *DCMT Diecasting Machines*

1211. Die Casting Machines
New bulletin on model 400-N die casting machine for aluminum, brass, magnesium, zinc, lead and tin alloys. *Cleveland Automatic Machine Co.*

1212. Die Steel
Folder on steels for plastic molding and die casting. *Crucible Steel*

1213. Dynamometers
4-page folder on precision dynamometers for measuring traction, tension or weight. Capacities from 0 to 500 lb. to 0 to 100,000 lb. *W. C. Dillon*

1214. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

1215. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1216. Electric Melting
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1217. Electron Tubes
8-page directory of interchangeability of Machlett tubes with others. *Machlett Laboratories*

1218. Electroplating
Bulletin on electroplating lists key characteristics of 16 processes. *Hanson-VanWinkle-Munning*

1219. Fasteners
New 24-page booklet covers technique of manufacture, proper installation, bibliography. *National Machine Products Co.*

1220. Fasteners
64-page catalog of stainless steel fasteners lists 9000 items and sizes in different stainless analyses. *Anti-Corrosive Metal Products*

1221. Fatigue of Magnesium
18-page paper, "Plastic Flow and Work Hardening Phenomena in Magnesium Alloys During Fixed-Deflection Fatigue Tests". *Dow Chemical*

1222. Ferro-Alloys and Metals
104-page book gives data on more than 250 different alloys and metals produced by the company. *Electro Metallurgical*

1223. Filters
32-page booklet on filters, mixers, pumps and tanks for liquid processing. *Alsop Engineering*

1224. Finishing
Two 8-page bulletins on dip tank and flow coat finishing describe processes, advantages and disadvantages of each. *Du Pont Finishes Div.*

1225. Finishing Barrel
Data on new heavy duty barrel for fin-

ishing stamped, forged and machined, cast parts. *Lord Chemical*

1226. Firebrick
New 28-page bulletin R-34 on properties and characteristics of 5 kinds of firebrick. Typical applications. Tables of brick quantities for arches of different sizes and shapes. *Babcock & Wilcox, Refractories Div.*

1227. Flaw Location
New 4-page pamphlet discusses all aspects of flaw location with dye penetrants from precleaning to interpreting results. *Turco Products*

1228. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1229. Forging Hammers
24-page brochure describes construction and use of steam drop hammers. *Erie Foundry*

1230. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1231. Forgings
6-page brochure on cored forgings of aluminum and other nonferrous metals. Advantages. *Weatherhead Co.*

1232. Formed Shapes
New 26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

1233. Furnace Maintenance
16-page "Maintenance Guide for Electric Heat Treating Furnaces" on preventive program. *Hevi Duty Electric*

1234. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

1235. Furnaces
Bulletin 424R on gas, oil, and electric revolving retort furnaces for annealing, hardening, drawing. *W. S. Rockwell Co.*

1236. Furnaces
32-page catalog of industrial equipment includes furnaces and furnace accessories, special valves, mechanical equipment, materials handling equipment. *Salem-Brosius*

1237. Furnaces
Brochures on pot furnaces, nitriding, austempering, and martempering and salt baths. *A. F. Holden*

1238. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

1239. Furnaces
Suggestions and check points for proper service and maintenance of furnaces are included in March Metal Minutes. *Sunbeam Corp.*

1240. Furnaces
High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1241. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1242. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

1243. Graphite
20-page brochure on significance of graphite as electrodes, anodes, molds and specialties in electrometallurgy and electrochemistry. *Great Lakes Carbon*

1244. Graphite Molds
Data on two types of molds for casting magnesium, steel, copper, brass and other metals. *National Carbon*

1245. Grinding Magnesium
Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

1246. Hardness Tester
Bulletin on Brinell tester with test head for deep and offset testing. *King Tester Co.*

1247. Hardness Tester
13-page booklet on microhardness tester with optional Vickers or Knoop diamond. *Geo. Scherr*

1248. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

1249. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

1250. Hardness Tester
Data on portable tester with five most widely used hardness scales. *Co. for Technical Progress*

1251. Hardness Tester
4-page bulletin on tester for both superficial and regular hardness testing. *Torsion Balance Co.*

1252. Hardness Tester
New bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

1253. Hardness Testers
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage International*

1254. Hardness Testers
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1255. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

1256. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1257. Heat Resistant Alloy
6-page bulletin on high-heat resistant muffles and retorts. *Electro-Alloys*

1258. Heat Treating
Data sheets on tempering salts, neutral salts, quenching oils. *Swift Industrial Oils*

1259. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1260. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

1261. Heat Treating
Reference sheet gives procedures for preparing parts for heat treating. *Metal Treating Institute*

1262. Heat Treating Aluminum
New bulletin SC-171 on furnaces, soaking pits, annealers, batch units for heat treating, melting, investment casting aluminum and other light alloys. *Surface Combustion*

1263. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1264. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

1265. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1266. Heat Treating Fixtures
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1267. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

1268. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

1269. Heliarc Welding
Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde*

1270. High-Alloy Fabrication
4-page bulletin on high-alloy assemblies for chemical, petroleum, food, petrochemical, pharmaceutical and other process industries. *General Alloys*

1271. High-Frequency Welding
Report on making aluminum tubing by high-frequency resistance heat method at Aluminum Co. of Canada. *New Rochelle Tool*

1272. High-Strength Steel
New 24-page booklet gives technical information and applications of high-strength, weldable, alloy steel. *Lukens Steel*

1273. High-Temperature Steels
87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

1274. High-Vacuum Furnaces
12-page brochure No. 790 on vacuum furnaces for melting and casting titanium, zirconium, germanium, copper, iron and steel. Also furnaces for annealing, hardening, brazing. *F. J. Stokes*

1275. Humidity Recorders
New 6-page bulletin on portable recorders for humidity and temperature. *Bristol Co.*

1276. Hydrogen Atmosphere
Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to −70° F. *Baker & Co.*

1277. Induction Furnace
New 4-page folder on combination induction melting and holding furnace and automatic pouring unit. *Ajax Engineering*

1278. Induction Hardening
Bulletin M-1938 on induction hardening machine gives advantages and application of system. *Cincinnati Milling Machines*

1279. Induction Heaters
New bulletin on low-frequency induction heating describes units for brass, copper, titanium, steel, forgings, light metal extrusion presses. *Magnethermic*

1280. Induction Heating
12-page booklet B-6519 on equipment for induction heating for forging, hardening, annealing and metal joining. *Westinghouse Electric*

1281. Induction Heating
New 12-page bulletin gives descriptions, technical data on various sizes. Water systems diagrams and standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

1282. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1283. Induction Melting
16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and nonferrous metals. *Ajax Electrothermic*

1284. Industrial Fans
New bulletin C-102 on fans for hot air and gases to 600° F. describes application of forward and backward curving blade fans. *Chicago Blower*

1285. Industrial Heating
20-page handbook classifies industrial ovens and gives pointers on oven selection. *Michigan Oven Co.*

1286. Inert Gas Welding
New catalog on CO_2 systems for welding. Gas flow obtained from each unit and typical welding applications. *Pure Carbonic Co.*

1287. Instruments
Bulletin 70-105 on Protectron for mechanical overload detection. *Sperry Products*

1288. Instruments
34-page book describes 37 instruments for electrical, physical, resistance-welding, ultrasonic and other measurements. *Brush Electronics*

1289. Instruments
New bulletin on manometer-type instruments for pressure, flow and liquid level. *Meriam Instrument*

1290. Instruments
20-page booklet on Hilger optical instruments including absorptiometer, spectrophotometer, comparator, spectrographs, microscopes. *Jarrell-Ash*

1291. Insulation
New 20-page catalog on thermal insulations and refractories for application at −400° F. to +3000° F. Composition, physical and thermal properties. *Johns-Manville*

1292. Ion Exchange
6-page reprint on treatment of certain plating solutions by ion exchange. *National Aluminate Corp.*

1293. Laboratory Furnace
Box furnace with cooling chamber for use to 3100° F. described in bulletin GEA-4713. *General Electric*

1294. Laboratory Furnace
Bulletin 1016 on single and dual tube furnaces for combustion analysis. *Sentry*

1295. Laboratory Mill
4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

1296. Laboratory Supplies
Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

1297. Leaded Steel
8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

1298. Low-Alloy Steel
60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U. S. Steel*

1299. Low-Temperature Properties
48-page bibliography of characteristics of steels at low temperature covers 1904 to June 1953. *Inco*

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1300. Lubricant
Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Corp.*

1301. Lubricants
8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. *Grafo Colloids*

1302. Lubricants
Newly revised 4-page booklet on graphite, molybdenum disulfide, mica vermiculite, zinc oxide and acetylene black. Carriers, diluents, applications and physical data. *Acheson Colloids*

1303. Machining Stainless
Bulletin TDC-182 on various machining operations on stainless pipe and tubing. *Babcock & Wilcox*

1304. Magnesium Alloys
12-page booklet on Magnesium Base Alloys, Alloy Nomenclature and Temper Designation recommends standard designations for use on prints and by purchasing agents. *Magnesium Assoc.*

1305. Marking Dies
New 26-page handbook on marking with steel dies. Use and selection of steel dies for every application. Stamping, embossing, foil leaf marking dies. Holders. *Jas. H. Matthews*

1306. Mechanical Cleaning
Booklet on how brushes are used for cleaning welds, stainless sheets, hot cast iron, automotive parts, brass fixtures. *Brush Div., Pittsburgh Plate Glass*

1307. Melting Furnace
Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg Engineering*

1308. Metal Cutting
64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

1309. Metallograph
12-page book on desk-type metallograph. *American Optical*

1310. Metallograph
20-page booklet, E-232, on Balphot all-purpose metallograph—bright field, dark field, polarized light, phase contrast. *Bausch & Lomb*

1311. Metallurgical Apparatus
200-page catalog of metallurgical apparatus: cutters, grinders, mounting presses, polishers, metallographs, microscopes, cameras, testing machines, analytical apparatus, spectographs, furnaces, accessories and supplies, and 250 recommended metallurgical books. *Buehler, Ltd.*

1312. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1313. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1314. Molybdenum
New folder on pallet method of shipping molybdenum. *Molybdenum Corp.*

1315. Molybdenum Silicides
Two new publications, Refractory Molybdenum Silicides and Fabrication of Molybdenum Disilicide Parts, condense information on properties, applications, preparations. *Climax Molybdenum*

1316. Moly-Sulphide Lubricant
40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

1317. Monel
New booklet on engineering properties of cast Monel. *International Nickel Co.*

Participants in the April meeting of the Metal Powder Association made the following literature available. For further information on this meeting see the May issue of Metals Review.

1412. Powdered Metals
Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc Co.*

1413. Sintering
Colorful 8-page folder on batch and continuous-type sintering furnaces and atmospheres for sintering. *Lindberg Engineering Co.*

1414. Tablet Presses
4-page folder on Big 4 series of automatic tablet presses. Features include triple x seal against contamination, self-lubrication, upper and lower punch pressure. *Kux Machine Co.*

1415. Plast-Iron Powder
4-page data folder gives strength and growth properties of Plast-Iron Grade B-261; includes cost comparisons. *Plastic Metals Div., National-U.S. Radiator Corp.*

1416. Sponge Iron Powder
Nine graphs in 4-page folder give data on strength, sintering time, density, compacting pressure, for Ancor 80 sponge iron powder. *Hoeganaes Sponge Iron Corp.*

1417. Machine Parts
Metal powder parts for aircraft, automotive, farm equipment and textile industries are pictured in 6-page folder. Filter bronze, friction materials and bearings. *Powdercraft Corp.*

1418. Iron and Bronze Powder
Bearings, bushings and structural parts of iron and bronze powder described in 4-page leaflet. *Johnson Bronze Co.*

1419. Mechanical Press
Bulletin describes press for forming powdered metals, including capacity, tablet diameter, depth of fill. *Haller, Inc.*

1420. Iron Powder
8-page data folder gives properties and characteristics of new iron powder, Type B, produced by Alan Wood Steel Co. and offered by *Welded Carbide Tool Co., Inc.*

1421. Powder Press
Dorst automatic press for powdered metal is described in bulletin. Pressure, ram stroke and other specifications. *Arnhold Ceramics, Inc.*

1423. Powder Metallurgy
Vol. 1, No. 3 of Powder Metallurgy Progress presents articles on powder metal parts used in sanders, kitchen ranges and pneumatic tools. *Metal Powder Assn.*

1424. Compacting Press
4-page folder, Bulletin 3104, presents specifications and features of the Model L compacting press for powdered metal. *Baldwin-Lima-Hamilton Corp.*

1425. Metal Products
16-page brochure illustrates many typical products made of powdered metal, gives engineering data on iron base and copper base alloys. *Powdered Metal Products Div. Yale & Towne Mfg. Co.*

1426. Stainless Powders
4-page leaflet gives operational steps in producing sintered parts from stainless steel powders. *Alloy Metal Powders, Inc.*

1427. Metal Parts
Many powder metal parts are pictured and design suggestions presented in discussion of Camet powdered metal parts. *Chicago Powdered Metal Products Co.*

1428. Iron Powders
Attractive and colorful 32-page booklet contains comprehensive discussion of Carbonyl iron powders, including data on quality control, electromagnetic data, design, stability. *Antara Chemicals Div., General Dyestuff Corp.*

1429. Powdered Metals
Booklet tells how things are made of powdered metals, applications and future possibilities. *Stokes*

1430. Powder Metallurgy
12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever Co.*

1431. Furnaces
6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

1432. Bibliography
4-page folder presents extensive powder metallurgy bibliography for 1954 and 1955. *Harper Electric Furnace Corp.*

1318. Nickel Alloys
38-page handbook on wire, rod, strip of Monel, Inconel, nickel and nickel clad copper. *Alloy Metal Wire Co.*

1319. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

1320. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

1321. Oil Filter
New 4-page bulletin on the filtration of quenching oils. Changes in oil which result from repeated quenching operations. *Industrial Filtration*

1322. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1323. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

1324. Openhearths
Brochure on modern openhearth design and construction. *Loftus*

1325. Optical Instruments
64-page catalog of optical aids includes some industrial quality control tools—instruments, microscopes, comparators. *Edmund Scientific*

1326. Ovens
Bulletin 109 on laboratory and production ovens. Engineering, construction and control features. *Despatch Oven*

1327. Pickling
80-page book, "Efficient Pickling", covers all variables of process. Many charts and tables. *American Chemical Paint*

1328. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1329. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1330. Pickling Solutions
Data on acid additive for pickling. *Swift Industrial Chemical Co.*

1331. Plating Equipment
New 4-page bulletin on the advantages

(Continued from page 31)

of the germanium rectifier and its features. *Hanson-VanWinkle-Munn*

1332. Plating Solutions

New 4-page bulletin on potassiu anide describes its purity, handling, and quality control. *Koppers Co.*

1333. Plating Solutions

Operating manuals for plating metal fluoborate solutions. *Ba Adamson.* See page 165.

1334. Potentiometer

New 64-page bulletin P1245A o tronic potentiometer and bridge ments for recording, controlling.

1335. Powder Metals

Data on lubricant for oil impre sintered metals. *Alpha Molykote*

1336. Powdered Metal Pa

Technical data sheet on brass suitable for powdered metal parts, compositions and properties. *Dixo alloy*

1337. Precision Casting

8-page bulletin on investment c of various ferrous and nonferrous *Engineered Precision Casting*

1338. Presses

New 4-page brochure on hy presses for bending, cogging, fl forging, forming, straightening a setting operations. *R. D. Wood*

1339. Pyrometers

Catalog 168 on surface pyromet surface and subsurface temperatur ings. *Pyrometer Instrument*

1340. Pyrometers

32-page thermocouple and ac bulletin. *West Instrument*

1341. Quenching

Bulletin No. 11 on quenching o discusses advantages of quench ag *Sun Oil Co.*

1342. Quenching Oil

Book on mechanism of que properties of quenching mediums, curves. *Gulf Oil*

1343. Radioactive Chemic

24-page booklet describes radi chemicals and their uses. Lists available. *Baker & Adamson*

1344. Radiography

26-page brochure on very high equipment for radiography and ho used. *High Voltage Engineering*

1345. Radiography

28-page booklet on products for

(Continued from page 31)

of the germanium rectifier and its special features. *Hanson-VanWinkle-Munning*

1332. Plating Solutions

New 4-page bulletin on potassium cyanide describes its purity, handling, safety and quality control. *Koppers Co.*

1333. Plating Solutions

Operating manuals for plating with metal fluoborate solutions. *Baker & Adamson.* See page 165.

1334. Potentiometer

New 64-page bulletin P1245A on electronic potentiometer and bridge instruments for recording, controlling. *Bristol*

1335. Powder Metals

Data on lubricant for oil impregnated sintered metals. *Alpha Molykote*

1336. Powdered Metal Parts

Technical data sheet on brass alloys suitable for powdered metal parts, giving compositions and properties. *Dixon Sintalloy*

1337. Precision Casting

8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1338. Presses

New 4-page brochure on hydraulic presses for bending, cogging, flanging, forging, forming, straightening and upsetting operations. *R. D. Wood*

1339. Pyrometers

Catalog 168 on surface pyrometer for surface and subsurface temperature readings. *Pyrometer Instrument*

1340. Pyrometers

32-page thermocouple and accessory bulletin. *West Instrument*

1341. Quenching

Bulletin No. 11 on quenching oil also discusses advantages of quench agitation. *Sun Oil Co.*

1342. Quenching Oil

Book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

1343. Radioactive Chemicals

24-page booklet describes radioactive chemicals and their uses. Lists those available. *Baker & Adamson*

1344. Radiography

26-page brochure on very high voltage equipment for radiography and how it is used. *High Voltage Engineering*

1345. Radiography

28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

1346. Radiography

16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman*

1347. Residual Stresses

Influence of Grinding Fluids Upon Residual Stresses in Hardened Steel, an 8-page reprint including discussion and figures. *Mellon Institute.*

1348. Rhodium Plating

Data on properties, thicknesses required, costs, operation, applications. *Technic*

1349. Rust Prevention

72-page book on cleaning, preservation, and packaging of metals. Causes of corrosion. *E. F. Houghton*

1350. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

1351. Saw Blades

Selector for hand or power blades tells which blade to use for various alloys and shapes. *Henry Disston*

1352. Saws

Catalog C-53 describes 35 models of metal-cutting saws. *Armstrong-Blum*

1353. Shell Molding

New 12-page brochure describes production and advantages of shellcast products. *Electric Steel Foundry Co.*

1354. Shell Molding

Bulletin on shell-molded castings service lists ferrous and nonferrous alloys handled and parts produced. *Crobalt*

1355. Slitting

76-page book on slitting lines for coils and sheets. Design, selection, operation, time studies of operating cycle. *Yoder*

1356. Sodium

Revised booklet on handling metallic sodium gives typical sodium using processes, equipment installation, recommendations for pumping and instrumentation. *U. S. Industrial Chemicals*

1357. Soldering

Quick reference chart to melting points of all solder alloys. *Anchor Metal*

1358. Sonic Thickness Tester

Measurement of wall thickness from one side by sonic method. *Branson*

1359. Specifications Index

28-page cross index lists copper alloy specifications of nine different Government agencies. *American Brass*

1360. Stainless Castings

11 reference sheets for major stainless casting alloys give compositions, properties, resistance to corrosive solutions, machinability, heat treatment, weldability. *Cooper Alloy*

1361. Stainless Fastenings

20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

1362. Stainless Steel

Selector gives machinability, physical and mechanical properties, corrosion resistance of various grades of stainless steel. *Crucible Steel*

1363. Stainless Steel

Wall chart gives engineering properties of 20 different stainless steel alloys available in wire, rod and strip. *Alloy Metal Wire*

1364. Stainless Steels

10-page booklet contains charts, graphs, data on cold rolled mechanical properties, elevated temperature properties, physical properties and corrosion resistance of chromium-nickel-manganese steels. *Allegheny Ludlum.*

1365. Stainless Wire

New bulletin includes analyses, tensile strengths, physical properties and gages of 12 types of stainless wire. *Carpenter Steel, Webb Wire Div.*

1366. Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

1367. Steel 52100

New stock list on 52100 tubing, bars and ring forgings. *Peterson Steels*

1368. Steel 52100

Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1369. Steels

New 102-page edition of catalog of alloy and stainless steels gives technical data on alloys, alloys for use in various industries, company's products in each alloy. *Electric Steel Foundry Co.*

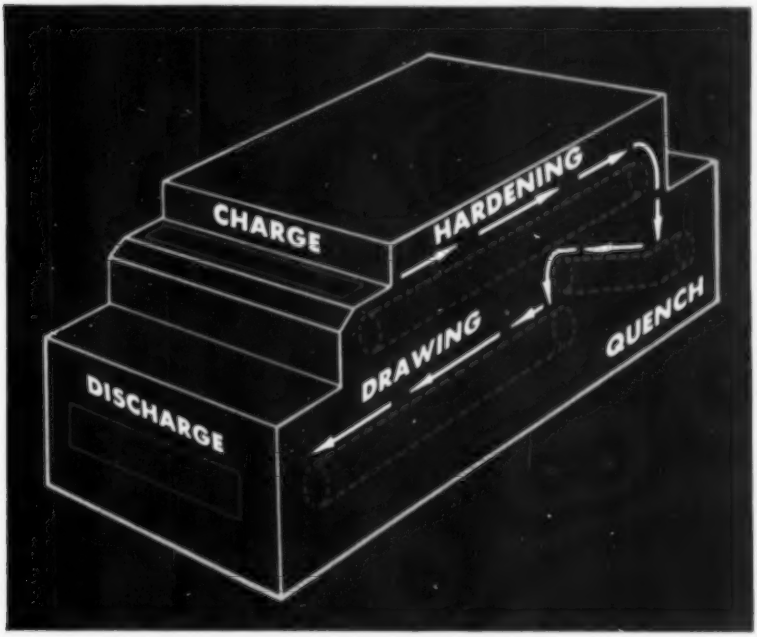
1370. Steels for Pressure Vessels

New 12-page booklet compares carbon and alloy steels at various temperatures as to service and cost. *Lukens Steel*

1371. Stereomicroscopes

38-page catalog D-15 shows value of three-dimensional microscopes for industrial assembly lines and research laboratories. *Bausch & Lomb Optical*

BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT



LET'S TALK ABOUT
DOUBLE DECK FURNACES

Ever try to fit two entirely different furnaces into floor space where only one will go? It can be done. All you do is *stack one on top of the other!*

Holcroft did it first a good many years ago. The furnace illustrated—by no means the first of its type—was built for a Detroit automobile plant back in 1932.

Three thousand pounds of connecting rods and spindles each hour were treated—moving first through a hardening furnace on the upper deck and then down a chute into a quench tank. Work was elevated by means of a reverse conveyor from the tank and loaded onto the return conveyor belt of the lower furnace for drawing and discharge.

Furnaces like these can be fully automated, or have manual transfers. They can be designed to heat treat a specific part, or to be used for general production.

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CANADA: Walker Metal Products, Ltd., Windsor, Ontario

1372. Surface Measurement

8-page bulletin contains a description of ASA standard on surface roughness, waviness and lay. Basic definitions, how to designate these characteristics, types of roughness-height average. *Micrometrical Mfg.*

1373. Surface Temperature

Bulletin No. 4257 on Pyrocon, surface temperature instrument. *Illinois Testing Laboratories*

1374. Temperature Control

8-page booklet R-22 on equipment to detect and correct thermocouple circuit failure in heating and melting operations. *Peerless Electric*

1375. Temperature Control

Bulletin on temperature-monitoring system to signal existence of dangerous temperature at one or more points. *Thermo Electric Co.*

1376. Temperature Conversion

16-page temperature conversion booklet and electromotive force of thermocouple alloys in absolute millivolts. *Wheelco*

1377. Test Accessories

22-page Bulletin 46 on instrumentation, tools and accessories for mechanical testing machines. *Tinius Olsen*

1378. Test Specimens

Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1379. Testers

Data on portable spot tester for qualitative analysis. *Spot-Testers, Inc.*

1380. Testing Equipment

80-page illustrated catalog lists over 130 testing and measuring tools for laboratory and production-line use. *General Electric*

1381. Thermostats

New bulletin describes styles available, operating principles, performance data, ratings, dimensions. *Stevens Mfg. Co.*

1382. Thickness Measurement

Data sheet 10.9-1a on sheet and coating thickness measurement on a continuous basis. *Minneapolis-Honeywell*

1383. Tin

Folder on uses of tin for lubricating, as a fusing agent, barrier, opacifier, fixative, stabilizer, pesticide. *Malayan Tin Bureau*

1384. Titanium Alloy

Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

1385. Tool Steel

Two new bulletins on free-machining tool and die steels, Cromovan F. M. and Star-Mo F. M. *Firth-Sterling*

1386. Tool Steel

Wall chart showing more than 300 varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

1387. Tool Steel

Data sheets on high speed, hot work, air, oil and water hardening tool steels, alloy steels, machinery steels, stainless steels, welding rods. *Crucible Steel*

1388. Tool Steel Color Guide

Color guide to estimate temperatures has heat colors on one side and temper colors on the other. *Bethlehem Steel*

1389. Tube Welding

Bulletin on high-frequency tube welding equipment. Applications, materials which may be welded by this process. *New Rochelle Tool*

1390. Tubing

New 4-page bulletin TB-362 gives case histories for use of electric-resistance-welded carbon steel mechanical tubing. *Babcock & Wilcox*

1391. Tubing

52-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

1392. Tukon Tester

12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

1393. Tungsten

20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. *Sylvania Electric Products*

1394. Tungsten Alloy

Data on properties and uses of 95% tungsten alloy, balance nickel and copper. *Firth Sterling*

1395. Ultrasonic Testing

Bulletin on testing equipment for measuring thickness, lack of bond, laminar-type defects. *Magnaflux*

1396. Ultrasonics

New bulletin MW-103 on use of ultrasonics in degreasing, electroplating, drilling, and grinding operations. *Acoustica Associates*

1397. Vacuum Gages

32-page Catalog 7001 on gages for vacuums to 10^{-11} mm. Hg and pressures to 150,000 psi. *Minneapolis-Honeywell*

1398. Vacuum Metallizing

Bulletin 780 gives uses and advantages of vacuum metallizing, materials and properties of vacuum metallized coatings, the process, equipment. *Stokes*

1399. Vacuum Metallurgy

Information memo describes the high-vacuum technique and pumping systems. *Consolidated Vacuum Corp.*

1400. Vacuum Pumps

New 52-page catalog No. 425 on high vacuum pumps contains formulas and tabular data. *Kinney Mfg.*

1401. Vanadium in Steel

189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

1402. Welding Electrodes

Report No. W5410 on low hydrogen electrodes for high alloy steels. *Harnischfeger Corp.*

1403. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1404. Welding Magnesium

Article on inert-gas-shielded metal-arc welding of magnesium includes numerous illustrations and tables. *Dow Chemical*

1405. Wire Drawing

New 8-page booklet on continuous wire drawing machines for brass, copper, aluminum and other nonferrous metals. *Waterbury Farrel Foundry & Machine*

1406. Wire Mesh Belts

130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

1407. Wire Mills

12-page booklet on 2-high wire flattening mills and auxiliary equipment. *Waterbury Farrel Foundry*

1408. X-Ray

12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

1409. X-Ray Supplies

Bulletin on liquid X-ray developer, replenisher and fixer. *Philip A. Hunt Co.*

1410. Zinc

32-page booklet on zinc's role in controlling corrosion tells why zinc does not corrode easily, describes zinc coatings and applications of galvanized steel. *American Zinc Institute*

1411. Zinc and Cadmium Plate

Technical data sheets on use of Lusteron salts for zinc and cadmium plating. *Chemical Corp.*

MAY, 1956

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1129	1155	1181	1207	1233	1259	1285	1311	1337	1363	1389	1415
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1148	1174	1200	1226	1252	1278	1304	1330	1356	1382	1408	
1149	1175	1201	1227	1253	1279	1305	1331	1357	1383	1409	
1150	1176	1202	1228	1254	1280	1306	1332	1358	1384	1410	
1151	1177	1203	1229	1255	1281	1307	1333	1359	1385	1411	
1152	1178	1204	1230	1256	1282	1308	1334	1360	1386	1412	

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

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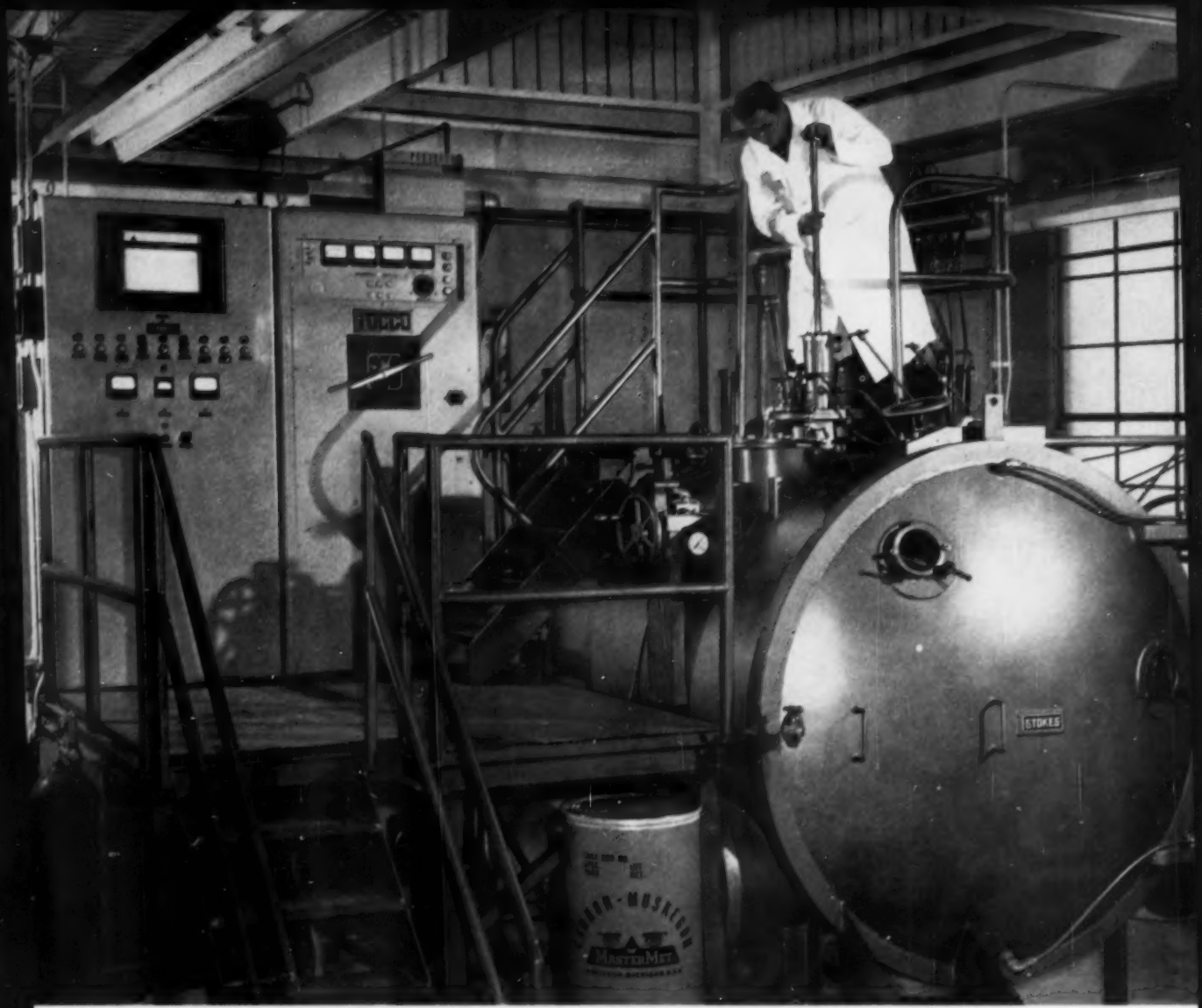
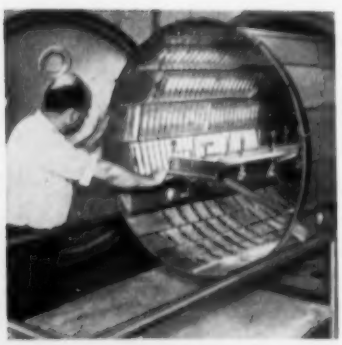
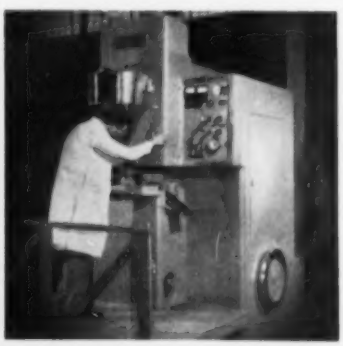


Due to Stokes vacuum lock design, operators can manipulate the melt during the heat without releasing vacuum. Furnace is used for production of special alloys at Cannon-Muskegon Corporation, Muskegon, Mich.

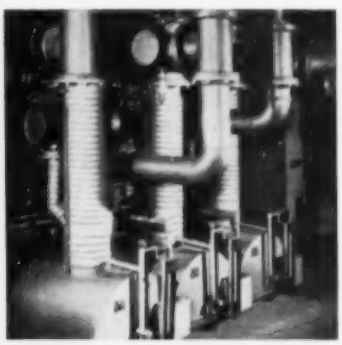
The metals industry is profiting from the use of other STOKES production equipment



Vacuum Metallizers. Stokes offers a complete line of vacuum metallizing equipment to plate metals for improved surface finish . . . also to provide conductive coatings on non-conductive materials.



Powder Metal Presses. Cost savings and the compacting of incompatible alloys have made powder metallurgy an accepted process. Stokes offers the most complete line of presses in the industry.



Vacuum Pumps. For rapid evacuation and holding high vacuums, Stokes offers mechanical pumps, and "Ring-Jet" oil vapor diffusion and booster pumps. New design affords 10 to 100% greater speeds.

"MasterMet" high temperature alloys vacuum melted in Stokes furnace

Another example of how Stokes vacuum furnaces aid industrial utilization of the new technology of vacuum metallurgy.

FOR the hot components of leading types of jet engines, Cannon-Muskegon produces a line of special vacuum melted alloys. Engineered primarily for high temperature service, these alloys are supplied as ingots and billets for investment casting.

A Stokes Vacuum Furnace provides performance to the exacting specifications required for this work. Its design is the result of close cooperation between Cannon-Muskegon and Stokes engineers. The furnace has a capacity of 500-pounds per heat.

In the words of George W. Cannon, Jr., company president, "The equipment has performed in accordance with our specifications . . . a leak rate of 8 microns per hour . . . and permits pouring of vacuum alloys at pressures less than 10 microns."

If you are planning to explore the interesting potential of modern vacuum metallurgy, plan, too, to take advantage of the undisputed leadership in equipment and experience which Stokes can apply to your problem. Prime supplier of vacuum furnaces for production use, Stokes incorporates the features you need for simplified operation and dependable service. With the Stokes vacuum lock, you can make multiple melts and manipulate the melt without breaking the vacuum. High capacity pumping systems, combining new Stokes Ring-Jet Booster Pumps and rugged Microvac roughing pumps provide fast evacuation and dependable holding of desired vacuum.

A Stokes engineer will be glad to consult on your specific application, help you select the most suitable of the many basic Stokes designs for your work, and engineer modifications to your special requirements. For technical data, write for Stokes Catalog No. 790, "High Vacuum Furnaces."

F. J. STOKES MACHINE COMPANY, *Vacuum Furnace Division*, 5506 Tabor Road, Philadelphia 20, Pa.

Reference Data:

Microvac Pumps—Catalog 750
Diffusion and Booster Pumps
Specification and performance data
Story of the Ring-Jet Pump
How to Care for Your Vacuum Pump—
Booklet 755
Vacuum Furnaces—Catalog 790
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The Precision Class 15 Line of *ElectroniK* instruments has calibrated accuracy within ±.25% of scale span. Models include strip and circular chart recorders, Precision Indicators, circular scale indicating controllers, Vertical Scale Precision Indicator. Electric and pneumatic control from simplest to most complex types. Multi-point monitoring or recording of 2 to 400 separate inputs.

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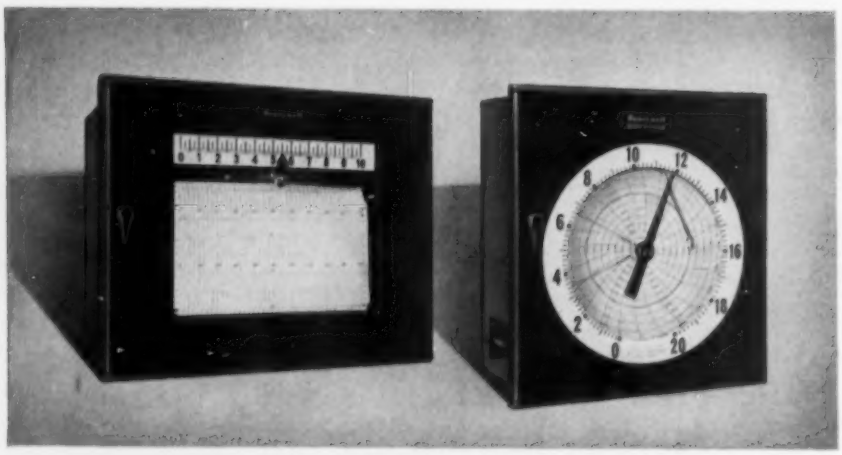

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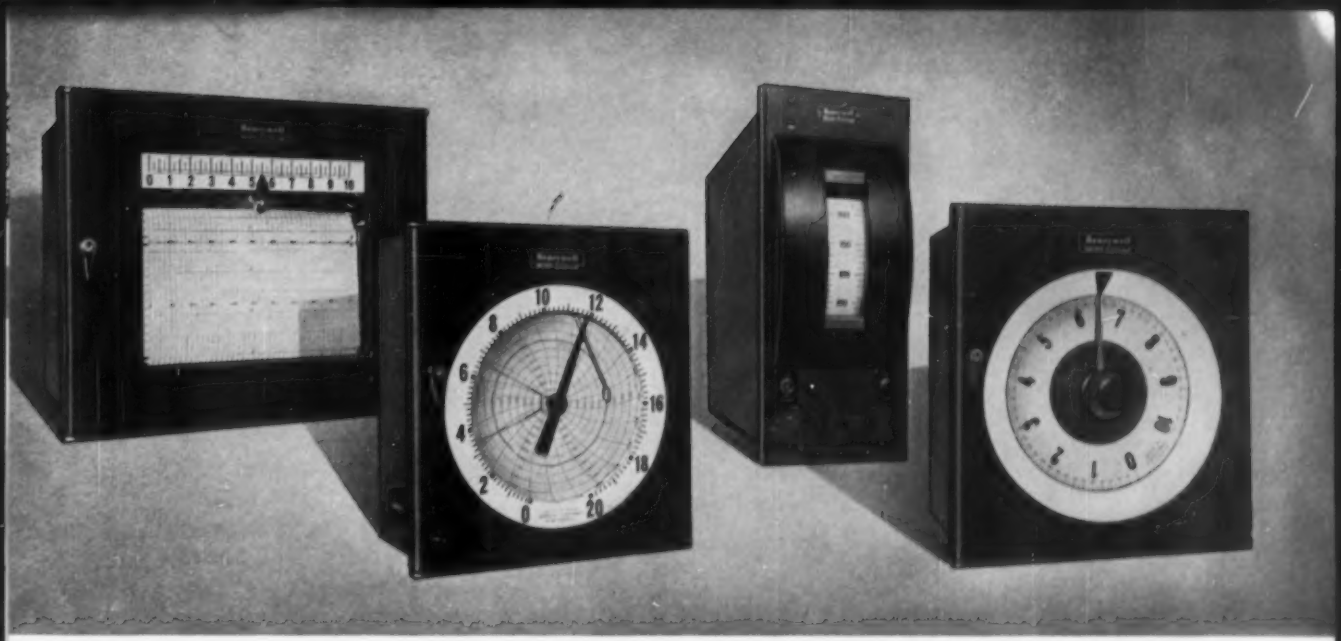

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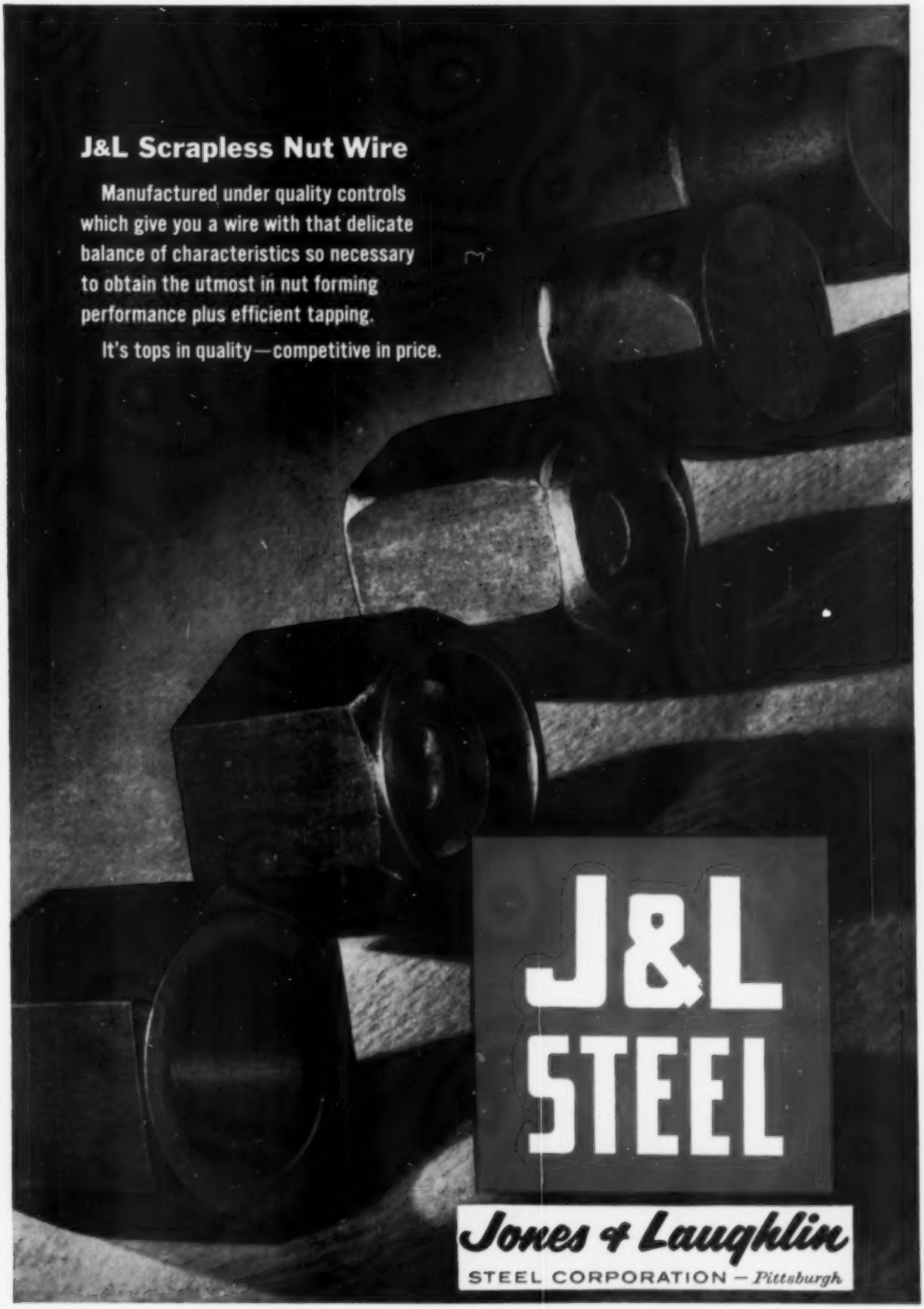
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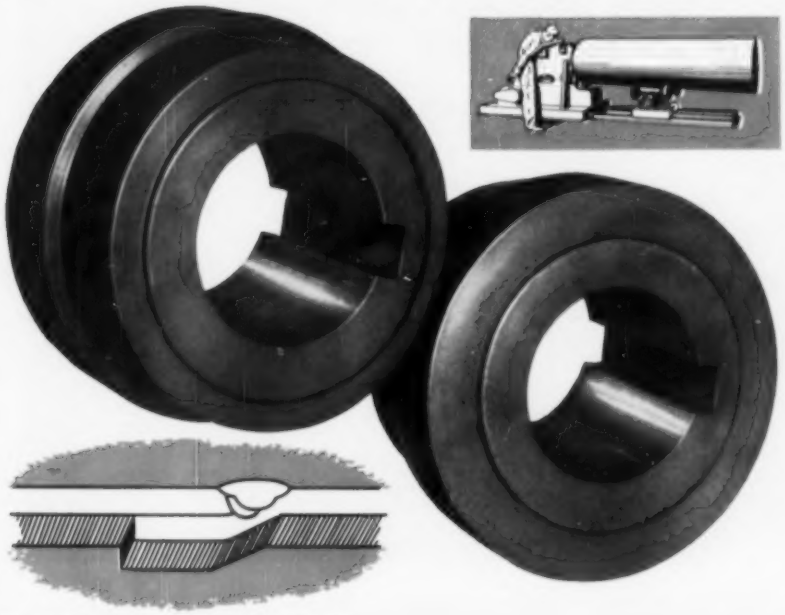
Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Hollow-Bar Dies Prove Economical for Forming Offset Joggle Joints



The Webb Corporation, Webb City, Mo., manufacturers of industrial and mining machinery, had been fabricating a special grade of alloy steel to make roller-type forming dies, similar to those shown above. The dies formed joggle joints on shell ends, in a machine which produces an offset flange around the ends of cylinders, as a backing for automatic welding.

"Now there's a place," we pointed out, "where we believe BTR Hollow-Bar tool steel can effect a saving. It comes with the hole already formed in the steel, so right at the start you save a lot of machining. And as for wear and dependability, we can let BTR Hollow-Bar speak for itself."

The change was made, BTR (Bethlehem Tool Room) Hollow-Bar being put to work forming ASTM-A212 steel plate, ½ in. thick. At Webb they are pleased with the results — not only the saving in machining, but with Hollow-Bar's wear-resistance and ease of heat-treatment.

BTR Hollow-Bar is made from our oil-hardening tool steel by a process called high-speed trepanning, by which hammer-forged round bars are cored out in the center, then rough-turned on the outside.

Hollow-Bar comes ready to go, virtually as soon as you receive it. There's no lost time waiting for forged rings or discs. Nor is there any need for drilling, rough-boring, rough-facing or rough-turning.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

3 Steps to Take When Tools Don't Harden

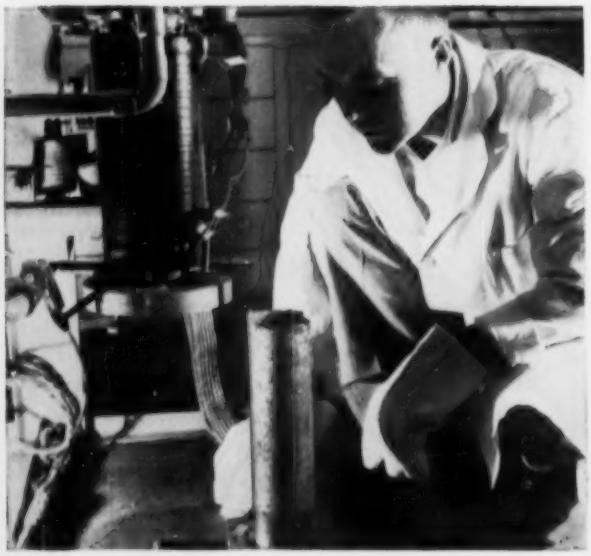
When tools do not harden properly in heat-treatment, it's a good idea to check first for mixed steel. This can readily be done either by means of spark-testing, or by experimentally hardening another piece of the same stock.

Next, recheck the hardness. Has the tool been ground below any possible decarburization which may have developed during heat-treatment? Was enough material removed from the original bar stock to get below decarburization? Has the hardness tester been checked against standards?

Third, investigate the heat-treatment practice. The most frequent causes of low hardness are: (1) the use of too low a quenching temperature, or too short a hold at correct temperature, (2) retained austenite, due either to an excessively high quenching temperature or an excessively high carbon carburized case, and (3) too slow a quench.

Though it pays to do the job correctly the first time, trouble-shooting of improper hardening has its place.

Steady Punching With Brake Die This picture, taken at Lyon Metal Products, Inc., York, Pa., shows Bethlehem Brake Die used as a punching die for ¼-in. diam holes in a steel-shelving panel. Brake Die provides good service in applications of this type because of its outstanding wear-resistance and toughness, and resistance to impact.



Research in titanium reduction and annealing by Dr. E. W. Johnson, Advisory Metallurgist, developed this vacuum arc furnace for commercial use. The consumable sponge titanium electrode, shown, is reduced to a highly pure titanium ingot.

Expanded design engineering is supervised by R. W. Brown, Engineering Manager, for Westinghouse gas and electric furnaces and atmosphere generators. Additional engineering facilities handle induction heating equipment.

Launching a new Industrial Heating Division

L. R. HAGUE OF WESTINGHOUSE CARRIES NEW PROFIT OPPORTUNITIES TO CUSTOMERS

Big and growing opportunities in metal treating are creating a need for broader equipment know-how and service. The answer to these needs is being put before customers by L. R. Hague, Division Manager, in over 10,000 miles of introducing Westinghouse major new Industrial Heating Division.

Cadre of key men

"Westinghouse new organization grows around key men with careers in metallurgical processing," reports Hague. "Their experience expedites problem solving on all types of equipment . . . gas and electric furnaces, atmosphere generators and induction heating equipment applications. Some of these involve more than one type of heat-treating and many installations incorporate work-handling advantages for in-line production."

Turn-key contracts

Manufacturing and field service organizations have expanded, too. They integrate their planning with customer timetables for equipment installation. Full erection and supervision of start-ups are provided in what Westinghouse calls *turn-key* contracts.

Research rapid

Hague points, in addition, to Westinghouse pioneering in new fields of metallurgy. "Developments in vacuum metallurgy, induction heating and other techniques are progressing rapidly," he said. "Equipment development is a part of Westinghouse large metallurgical research program."

On-the-spot planning

This year many plants plan heat-treating expansion. Many more will check heat-treating obsolescence—looking for troublemakers that cause extra handling, distortion, decarburization or scaling. "Call your local Westinghouse industrial heating sales engineer for counsel on these problems," Hague recommends. "He will bring broad equipment knowledge and service facilities for new profit opportunities." J-10449

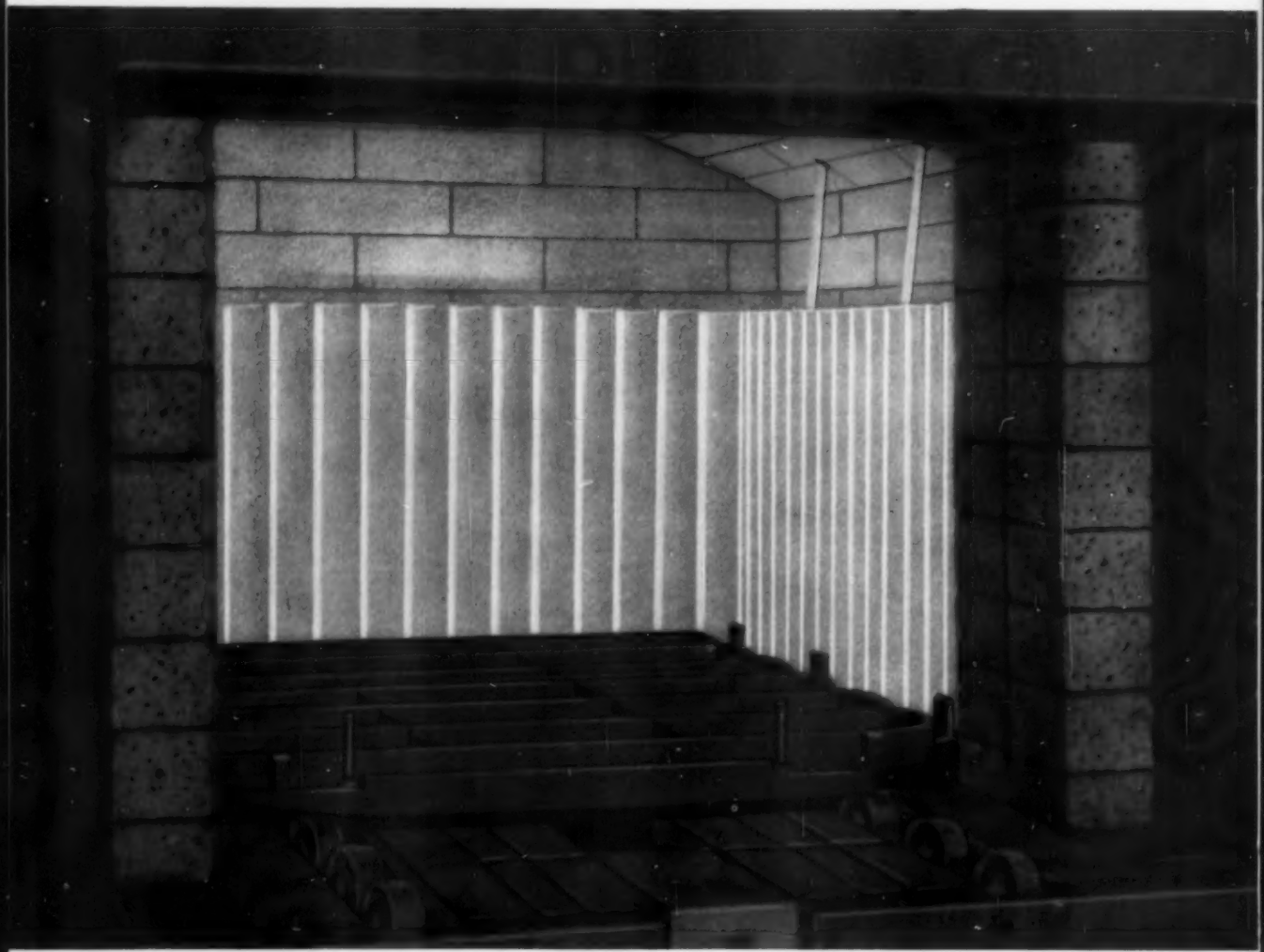
YOU CAN BE SURE...IF IT'S

Westinghouse

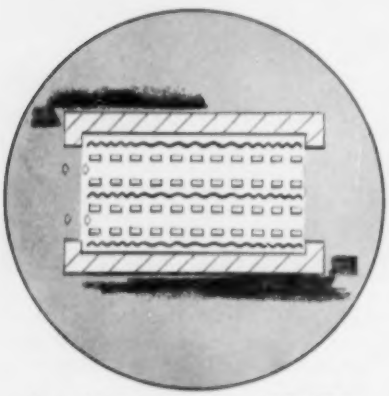
Project engineers, C. E. Peck and E. J. Seabold, work with Westinghouse customers in engineering, manufacture and installation of units such as this continuous annealing furnace, to be tested and ready to go in the customer's plant.

Industrial heating sales engineers are kept abreast of new developments and techniques in regular reviews with L. H. Gillette, Marketing Manager, and R. R. La Pelle, Furnace and Atmosphere Generator Application Manager.

BRAND NEW—MODERN ELECTRIC ELEMENT

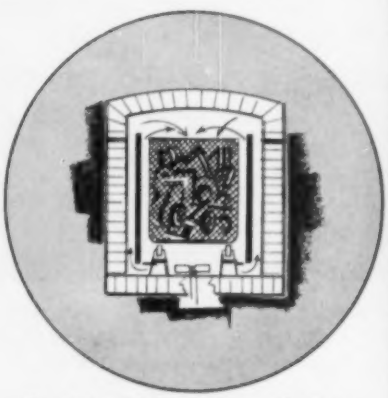


This shows graphically how the new Lindberg CORRTHERM electric heating element actually fills the furnace with walls of glowing heat. Note also that CORRTHERM is conveniently hung from simple brackets requiring no complicated connections or construction. This element operates at extremely low voltage, eliminating shock or short hazards.



In continuous type furnaces CORRTHERM elements hang between lines of work as well as on side walls. Note how closer corrugations (at each end of element) compensate for incoming cold work and door losses.

CORRTHERM elements act as natural baffles to direct forced convection streams through the charge. The use of electric furnaces for carburizing and carbonitriding now becomes completely practical.



No retort needed in pit-type carburizing furnace with CORRTHERM elements. Again see how elements serve as baffles to direct forced convection stream through charge.

FOR LINDBERG FURNACES

Never before has there been an electric heating element like this CORRTHERM by Lindberg. Its revolutionary advantages now make the use of electricity as the source of heat, practical, efficient and economical for all heat treating processes.

Ideal for use in any electric heat treating furnace, CORRTHERM elements have particular advantages for carburizing and carbonitriding. This new element completely eliminates problems formerly created by the use of electricity in these types of furnaces. These exclusive advantages of CORRTHERM explain how and why:

LOW VOLTAGE: Operates at extremely low voltage. No leakage through carbon saturation. Around Lindberg we talk about it as the electric element "without any electricity . . . to speak of!"

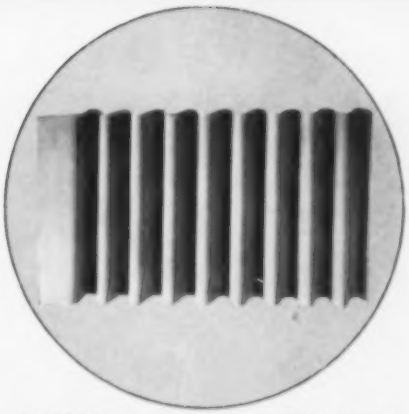
ATMOSPHERE CIRCULATION: Elements act as baffles to direct circulation of convection streams.

SAFETY: Extremely low voltage also eliminates shock or short hazards.

DURABILITY: Watts density at all-time low. Element practically indestructible. Work load or operator's charging tool can't hurt it.

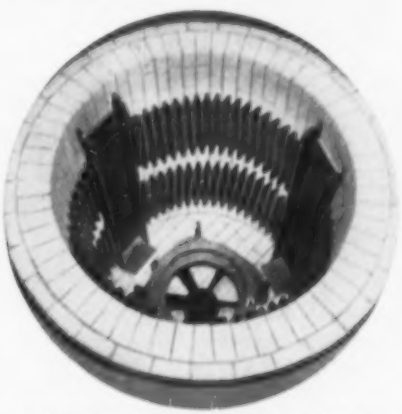
EASILY INSTALLED: Element is not enclosed, just hangs in furnace. No complicated mountings required.

If electricity is the preferable source of heat for your metal treating processes find out how advantageously CORRTHERM elements can be applied to your requirements. Just get in touch with your nearest Lindberg Field Representative. (Consult your classified phone book.)



CORRTHERM elements are large sheets of corrugated nickel chromium. They were developed in Lindberg laboratories by Lindberg metallurgists and engineers.

This shows installation of CORRTHERM elements in one of two large rotary furnaces currently being erected in the field by Lindberg's associate company, Lindberg Industrial Corporation.



An installation of CORRTHERM elements in a carburizing pit-type furnace. Simplicity of mounting makes replacement easy and economical.

LINDBERG

LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California

Associate Companies: Lindberg Industrial Corporation, Chicago • EFCO-Lindberg, Ltd., Montreal, Canada
Lindberg Italiana, Milan, Italy • The Electric Furnace Company, Ltd., Weybridge, Surrey, England
Etablissements Jean Aubé, Paris, France • Lindberg Industrie Ofenbau, Gross Auheim, Germany

Safety! Extremely low voltage makes CORRTHERM elements completely safe. Let operator or work load bang it if they will. Neither element nor operator will be hurt.

CORRTHERM

by LINDBERG

Centr-O-Cast & Engineering Co.,
Council Bluffs, Iowa

"Cities Service Heat Prover Showed Why Holding Pots Burned Out Prematurely!"

Put yourself in the place of Centr-O-Cast & Engineering Company.

You make permanent mold and centrifugal aluminum castings from 2 ounces to 65 pounds . . . and your products are so wanted that you've increased your business 50-fold since you began 10 years ago.

To meet this demand, you're now operating at a melting capacity of 1,500,000 pounds of aluminum per month, using 20 holding furnaces, two 500# melting furnaces, and two 800# melting furnaces.

Then suddenly—TROUBLE! One after another, holding pots start burning out prematurely . . . and you've got to find the reason and the solution *fast*.

How? Centr-O-Cast solved the problem by calling in their local Cities Service Lubrication Engineer—the man with the ingenious little troubleshooter known as the Cities Service Heat Prover.

Enabling simultaneous readings of oxygen and combustibles, the portable Heat Prover quickly determined excessive heat as the cause of the burnout and revealed what combustion adjustments were necessary. "Since then, there's never been a premature burnout due to improper combustion," says partner L. W. Wickson. "What's more—Cities Service has supplied this service free!"

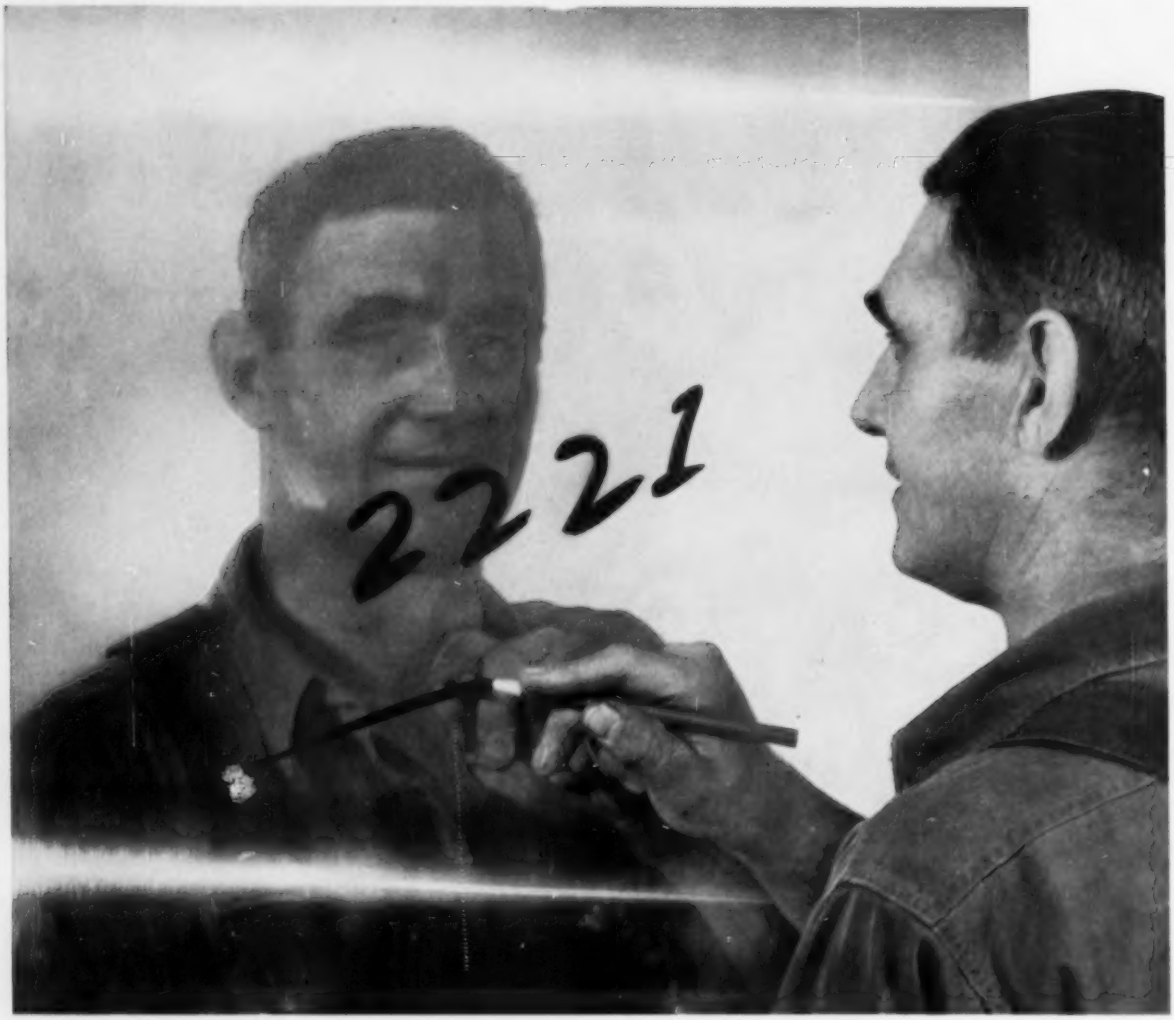
Nothing can be added to Mr. Wickson's statement except an invitation to you to try the Cities Service Heat Prover in solving your combustion problems. Talk with your Cities Service Lubrication Engineer or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

It Turned the Heat on a Burning Problem. The Cities Service Heat Prover was used by a Cities Service Lubrication Engineer to solve a costly problem of preliminary burnout in holding furnaces. Heat Prover showed cause and enabled necessary combustion adjustments.

Getting the Finishing Touch, castings of the Centr-O-Cast & Engineering Co. are smoothed off on grinding wheel. Principal markets are automotive, electrical and farm fields—whose heavy demand boomed Centr-O-Cast's sales to 50 times its 1946 volume.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



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Metal Progress
Volume 69, No. 5 May, 1956

"Gmoodie"– A Low-Cost Die Material

*By J. C. HOLZWARTH and A. L. BOEGEHOLD**

Forming dies made from a new zinc-base alloy will last three to four times as long as dies made from conventional zinc alloys. The greater life is due to a dispersion of hard Ni_3Ti particles in the matrix that increases wear resistance. (SG-j, Zn)

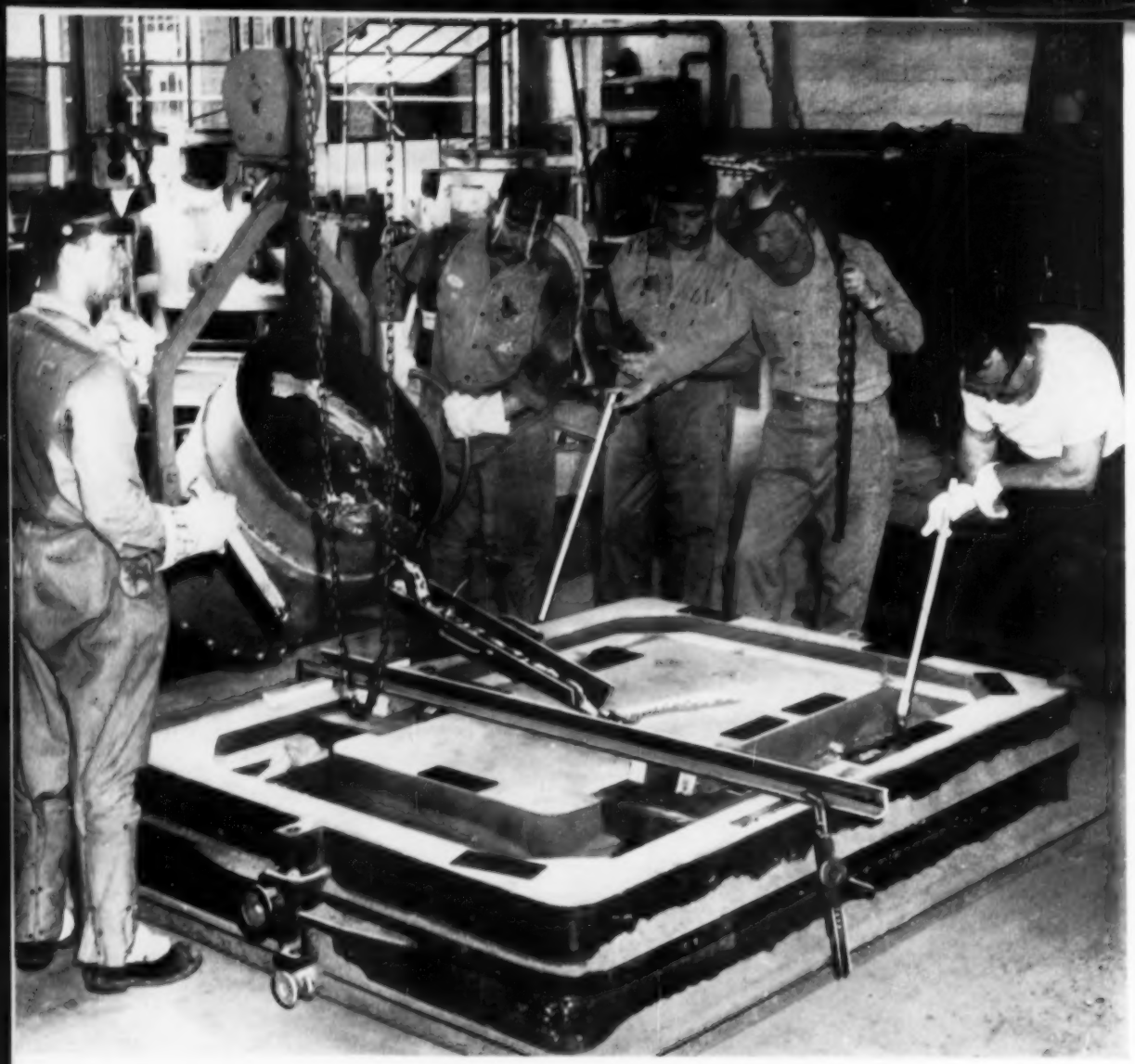
THE LOW-VOLUME producer of fabricated sheet metal parts has available several materials for producing low-cost tools, which include reinforced plastics and low-melting alloys of lead and zinc. Short-run dies can be produced quickly and inexpensively from these materials but often the die will wear out before anticipated production is completed. The volume may still be too low to justify the cost of an expensive cast iron die, so duplicate sets of the low-cost tool must be made. It would be most advantageous for the low or intermediate-volume manufacturer to have a material available which would outwear present short-run tools by a substantial margin, yet cost little more.

"Gmoodie"† is considered to be such a material. It was developed primarily for use in drawing, forming, flanging and bending tools for sheet metal where the volume of parts required exceeds the life expectancy of present low-cost tooling. Specifically, General Motors Overseas Operations (G.M.O.O.) required a die material with 50% greater productive life than the low-cost zinc-base dies that were being used. Such an improvement would permit them to produce nearly all sheet metal parts for vehicles and appliances with one set of dies for each part design.

The three major considerations were cost, castability and wear resistance. Existing zinc-base tool alloys fulfill two of these requirements. They are relatively cheap and readily available, and because of their low melting temperature, can be melted in simply constructed and maintained open-pot furnaces of cast iron or

*Respectively, Supervisor, Metallurgical Engineering Dept., and Assistant to Vice-President, Research Staff, General Motors Corp., Detroit.

†U. S. Patent No. 2,720,459.



Zinc-Base Die Materials Are Cast in Open Green Sand Molds Without Risers

steel. Tools and dies are usually cast in open green-sand molds, thus eliminating the necessity of using risers of any sort to feed the castings. This results in lower casting costs due to less scrap return, lower molding costs and less melting and handling equipment. Metal shrink is controlled by heating the open metal surface with torches and adding hot metal with a ladle as shrinkage occurs. The metal has uniformly controllable shrinkage, and with proper casting techniques, will give high-fidelity reproduction of the pattern. Finishing operations consist mainly of hand fitting and spotting in. Since very little finishing is required, the cost and time for putting the die into operation are relatively low.

Since existing zinc-base tool alloys fulfilled the cost and castability requirements, it was desirable to retain this basic composition and improve its wear resistance by additions of other elements. Soluble additives were not used even though they might increase the hardness by solution hardening because they would undoubtedly affect the melting point, fluidity and shrinkage characteristics. A more likely possibility was the addition of a dispersion of hard but relatively insoluble particles to the alloy which would produce wear resistance without affecting casting quality. These hard particles would be comparable to a network of carbides in ferrous alloys which improves resistance to rubbing wear.

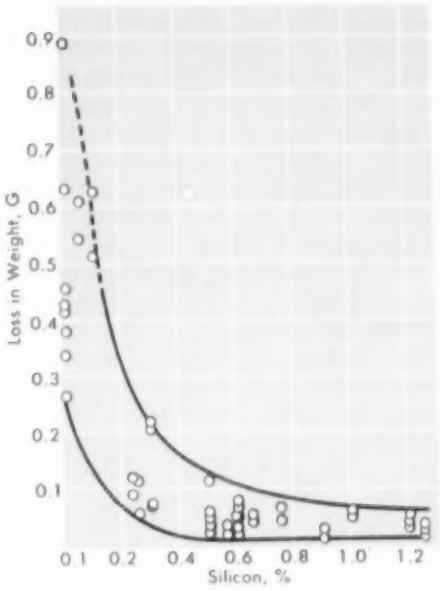
One of the challenging problems was to incorporate the relatively insoluble hard particles in the alloy. They must be wetted by the molten zinc alloy to be retained in suspension, yet they

must not have appreciable solubility or they would affect casting properties. This problem was solved by selecting suitable hard addition agents which are soluble in either copper or aluminum but not in zinc. Particle-forming elements can thus be introduced to the zinc in master alloys of copper or aluminum.

Silicon is soluble in aluminum, but relatively insoluble in zinc. When an aluminum-silicon alloy is added to molten zinc, the aluminum dissolves and the silicon is rejected as fine particles which are wetted by, but not soluble in the melt. These discreet hard particles of silicon greatly improve wear resistance. Wear properties were determined in a laboratory wear test by rubbing the samples of zinc alloy with a rotating soft steel wheel. Maximum wear resistance was obtained at about 0.6% silicon. Greater amounts of silicon showed very little additional improvement. Results of the bench test were confirmed later by production tests on sheet metal forming dies containing silicon. In several production runs, 90,000 parts were formed on dies containing silicon. This is at least four times as many parts as could be expected from similar dies without silicon. While the silicon particles improve wear resistance of the alloy, they tend to float in the higher-density melt because of their low specific gravity. Nonhomogeneous castings resulted in many instances, and the wearing qualities of such castings were generally better toward the top of the cast section than at the bottom. Since the sides and bottom of the mold cavity usually form the working surfaces, the upward migration of particles leaves a material which is essentially low in wear resistance. Furthermore, the stratification of hard solid particles into a semisolid layer on the open metal surface of a casting interferes with proper feeding during solidification.

The density of the particles could be increased by the addition of manganese to the zinc alloy with little effect on the wear resistance or casting properties of the alloy. Manganese does, however, have an indirect influence on wear properties of large castings since it controls the distribution of the hard particles.

Other techniques used to reduce segregation were *(a)* lowering the casting temperature and *(b)* agitation of metal prior to casting.



Effect of Silicon Content on the Wear Resistance of Zinc-Base Alloy

Lowering the pouring temperature below 780° F. increased the viscosity and density of the melt and also increased the solidification rate of the casting. Stirring of the melt before it was poured into the ladle and again before pouring into the mold cavity redistributed the particles which had stratified. Even though segregation was minimized by these methods, it still persisted to some extent in the larger cast sections. Furthermore, on successive remelts the alloy was gradually depleted in hard particles due to drossing so that its general level of wear resistance was lowered. The zinc-base tool alloy containing silicon and manganese* was alloyed and cast

*U. S. Patent No. 2,728,657.

Cost and Service Life of Dies for Refrigerator Panels

Cost Analysis	Conventional Zinc-Base Alloy	Gmoodie	Iron Die
Design, patterns and founding	$ 597.20	$ 597.20	$1560.00
Labor and overhead for machining, fitting and tryout	1115.90	1115.90	4400.00
Die material	690.00	840.00	640.00
Total	$2403.10	$2553.10	$6600.00
Credit for material recovered	621.00	756.00	90.00
Net Cost	$1782.10	$1797.10	$6510.00
Estimated stampings per die	8,000	30,000	200,000
With steel inserts	12,000	42,500	—

into dies by General Motors Overseas Operations for use in a number of their plants. A total of 410 tons was cast in fulfillment of this program. Because of segregation difficulties which persisted to some extent even with manganese present, further production was curtailed until a new hardening agent could be found which had greater density and less tendency to segregate.

The hardener which was finally selected to replace the low-density silicon was a combination of nickel and titanium believed to be the intermetallic compound Ni_3Ti. The new zinc-base alloy, known as Gmoodie, made with this hardener has wear resistance equal to that of the silicon-manganese modifications. In addition, it possesses much better castability and homogeneity, because the density of the hard particles matches the density of the melt. It can be cast in large sections with confidence that the die surface will have the desired wearing qualities. Unlike the silicon-manganese alloy, remelting actually appears to improve the wear resistance of this material.

Resistance to rubbing wear is again attributed to a dispersion of hard particles throughout the matrix. In order to obtain particles of the desired wearing characteristics the nickel and titanium are added to the zinc as a ternary alloy of copper, nickel and titanium. This alloy is composed of a dendritic network of nickel-titanium phase of the approximate atomic relationship Ni_3Ti, surrounded by copper-rich phase. The copper-rich phase is selectively dissolved, leaving solid particles of nickel-titanium compound suspended in the zinc-base melt. When the melt solidifies, these particles are trapped and firmly held within the matrix. An optimum combination of wear properties, castability and cost has been obtained in an alloy of about 4% aluminum, 3.25% copper, 0.80% nickel, 0.20% titanium, 0.15% magnesium and balance zinc. Representative mechanical properties are:

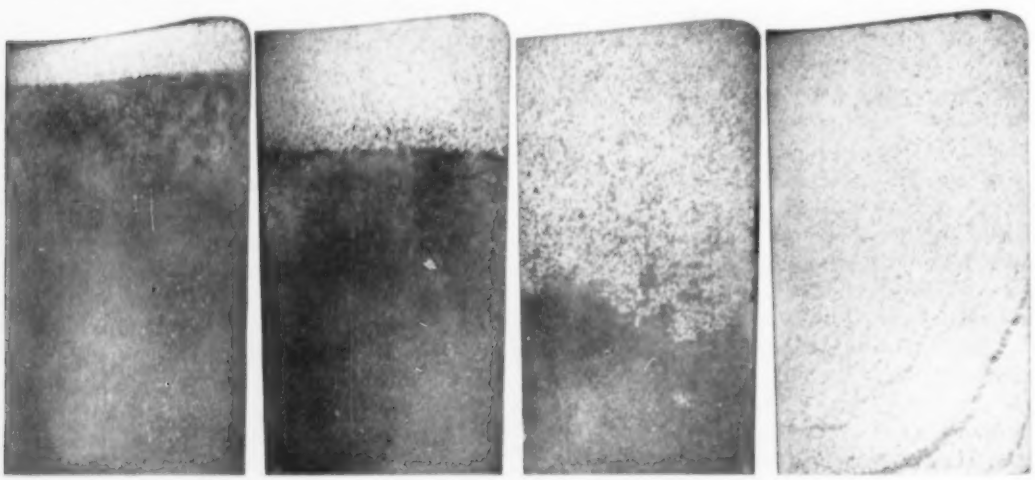
Tensile strength	10,000 psi.
Brinell hardness (500 kg.)	100 to 110
Melting point	750 to 760° F.
Shrinkage	7/64 in. per ft.

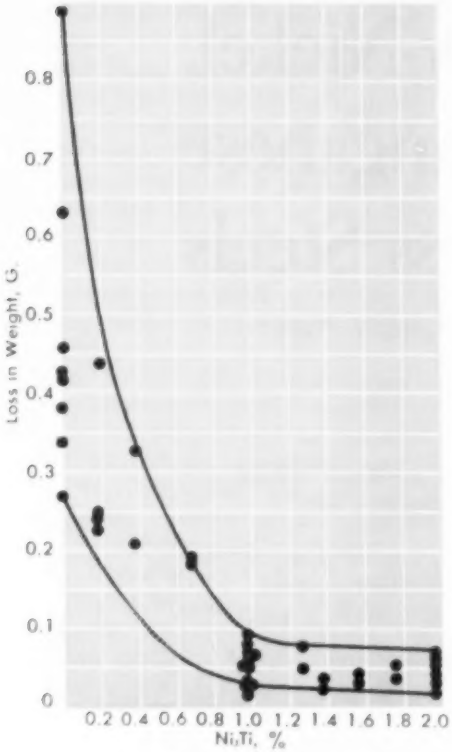
The alloy is made by dissolving aluminum ingot in molten zinc, then dissolving the copper-nickel-titanium hardener in this melt and finally adding magnesium to the bath. Since the density of the molten zinc decreases with superheat, long holding of the alloy without agitation in the furnace or ladle causes the particles to float gradually to the top of the melt and form a dense stratified layer. Agitation will help to prevent startification of the particles in the upper portion of the melt. The pouring temperature should be limited to 800° F. to insure uniformity of hard particles in the castings.

When used in drawing, forming, flanging, and bending dies, the material is capable of producing from 5,000 to 200,000 stampings, depending on the severity of the work. Where sharp edges or small radii are present, or where heavy gages or difficult materials are being worked, the die life will be shorter. Materials which have been formed on Gmoodie include cold rolled steel from 0.022 to 0.148 in. thick, aluminum from

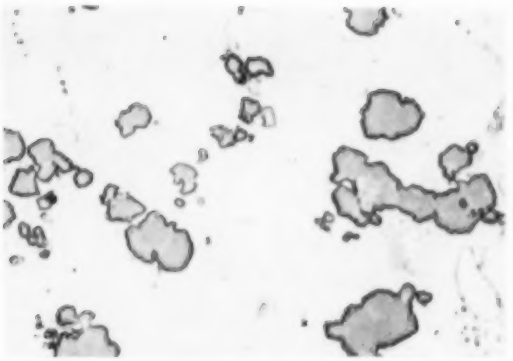
Effect of Manganese on Segregation of 0.60% Si Zinc Alloy Cast at 825° F.

No manganese *0.10% Mn* *0.30% Mn* *0.90% Mn*





Wear Resistance of Gmoodie as a Function of Ni_3Ti Content



Wear Resistant Nickel-Titanium Particles in Gmoodie. Unetched, 250×

0.022 to 0.060 in. and stainless steel in light gages. On similar dies, four times as many pieces can be formed on Gmoodie as on the conventional zinc-base alloy.

Cost and service life comparisons of three materials for the die set used to produce panels for a refrigerator are shown in the table on p. 53. The figures for the iron die made by conventional methods are based on quotations from a jobbing tool source. This includes making of patterns and profiling machine models as well as materials, all the necessary machining, fitting and tryout. The quotations from several reliable sources averaged $6600; figures as high as $8500 and as low as $3335 were also quoted. These were ruled out on the basis of past experience with the quoting firms on other jobs. The $6600 figures include some margin of profit in addition to material, labor and overhead.

In comparing costs, the material used is regarded as die cost in both instances. However, if the zinc-base die is for use within the plant of the maker and not for resale, expenditure for zinc-base material is usually regarded as capital investment rather than tooling cost. Since the material is almost fully recoverable and actually appears to improve on re-use, an arbitrary figure is usually set up to account for loss and depreciation on this investment. In this instance, the bookkeeping figure is 10%. On this basis, the total cost of the Gmoodie set is $1797.10. A conventional zinc-base tool costs about as much. There is only a slight difference in material cost and practically none insofar as founding and machining is concerned.

The estimated life of the three dies is based on the assumption that they are properly maintained. In this respect, the zinc-base dies require considerably more maintainance than the hard die. If the metal of the part has a tendency to wrinkle during the forming operation, rapid wear of the zinc-base dies will result. However, one advantage which offsets this disadvantage is the ability of the material to be built up safely and easily when wear does take place. Also, hard steel inserts may be used at the points of severe wear to extend life.

The choice of the material will depend on the anticipated production volume. A hard ferrous die might be the choice for volume in excess of 30,000 to 40,000 parts to insure continuity of production. However, it is possible to produce two, three, or even four zinc-base dies for less expenditure than one hard die, extending the life to 100,000 or more parts. The choice will have to be based in the estimated maintenance cost of multiple zinc-base tools.

Nearly 1,000,000 lb. of Gmoodie tools are now in use by General Motors Overseas Operations in foreign plants and there is also considerable domestic usage by other General Motors divisions. It is anticipated that the material will be commercially available to the sheet metal forming industry in the near future.

Fabrication of Low-Nickel, High-Manganese Stainless Steels

By RICHARD E. PARET*

The new series 200 stainless steels can be formed and welded with the same dies, equipment and techniques now used for the higher-nickel stainless steels.
The greater strength of the new alloys may require some modification in tooling for embossing or extremely precise deep drawing because of a slight increase in springback. (G general, K general, SS)

During 1955 the production of the low-nickel, high-manganese stainless steels, Types 201 and 202, amounted to less than 2000 tons. A recent survey of producers and fabricators, however, indicates that substantial quantities will be used during the current year by many American industries. Some industry leaders expect this growth to continue until these types will replace up to 80% of the higher-nickel Types 301 and 302. This expectation is closely tied to estimates of the future availability of nickel since austenitic stainless steels account for one-fifth of the U.S. nickel production. While nickel production is increasing, the rate of increase of stainless production has been substantially higher. Other demands for nickel have also increased.

Uppermost in the minds of fabricators who have turned to Types 201 and 202 is the corrosion resistance and service life which can be expected from these materials. No difficulty is expected from atmospheric corrosion since Cr-Ni-Mn steels have been in service for 15 years without any evidence of corrosion due to normal atmospheric conditions or common cleaning solutions. In 1942, the Budd Co. constructed some rail cars and truck trailers using the 17% Cr, 4 Ni, 4 Mn alloy and the units have been in service since that time. Budd has now standardized on Type 201 where Type 301 was previously used.

In marine atmosphere tests conducted by International Nickel Co., Cr-Ni-Mn samples were comparable in appearance to 18-8 Cr-Ni samples after nine years exposure. No decrease in tensile strength, yield strength or elongation occurred as a result of this exposure. Samples were not cleaned during this period and developed an oxide coating which could be removed with little difficulty.

To date, every test application of the Cr-Ni-Mn steels has been satisfactory in such items as home cooking utensils, sinks, restaurant equipment and transportation equipment. There is no indication that these steels will be limited in their replacement of Types 301 and 302 where the latter steels are being used properly.

In drawbench forming, roll forming and brake bending operations, 201 and 202 can be handled in exactly the same manner as 301 and 302 respectively. Operators at the Budd Co. have been unable to distinguish 201 from 301 when

*Committee of Stainless Steel Producers, American Iron and Steel Institute, New York. This is the third article in a series on the new stainless steels, A.I.S.I. Types 201 and 202; the first appeared in the December 1955 issue, the second in February 1956 *Metal Progress*.

they were intermixed in any of the forming operations.

In both shallow and deep drawing, the Cr-Ni-Mn types have behaved almost identically to their Cr-Ni counterparts with, however, some important exceptions. Usually, hold-down pressure must be adjusted to prevent wrinkling of the low-nickel steels due to their high yield strength. Since blank holding or hold-down pressure is a variable factor with almost every part produced, it is impossible to offer any specific recommendations as to the amount of change necessary.

In one instance, Cr-Ni-Mn steel was selected as a replacement for copper, even though Type 302 was at first considered for the application, namely, the body of a teakettle. Prior to changing to Type 202, production practice included two spinning operations on the dome and sidewall to smooth out wrinkles. Present indications are that either one or both of these operations can be eliminated with the new steel.

In another instance, the increased strength of Cr-Ni-Mn steels was found to be of major importance in the production of a drawn part. In the fabrication of a small sink drain, a spinning operation is required on the drawn piece to roll in a groove needed for attaching the drain.

Washfountain Bowl, 36 In. Diameter and 10 In. Deep, Is One of the Largest Pieces Thus Far Drawn in Type 202 Stainless

No Differences Have Been Observed Between Type 202 and 302 in Drawing, Curling, Polishing and Spot Welding Required for These Deep Drawn Cups

With Type 301, considerable distortion on the wall of the piece is found near the rolled groove. Type 202 cups are not distorted by the spinning-grooving operation.

Two instances were noted where extreme difficulty was encountered in drawing Type 201. These were a round mixing bowl and an automotive wheel cover for which scrap ran about 10%. To form the mixing bowl, hold-down pressure had to be reduced to an uncomfortable minimum (with attendant wrinkling) to achieve success at all. In the wheel covers, close tolerances must be held on the periphery because the covers must fit tightly over the locking devices, despite mechanical abuse in service. With the greater springback characteristic of Type 201, provision would have to be made to accommodate the larger diameter which results from the use of Type 201 with existing tooling. In each of these applications, however, the difficulty was traced to single lots of material and other lots were run through without any difficulty at all, indicating faulty metal rather than any basic difficulty with the Cr-Ni-Mn steel.

The higher strength of Cr-Ni-Mn steels usually will have an almost unnoticeable effect on production operations except possibly in embossing operations. In one instance small electric burner supports are sized, embossed and trimmed in one operation. With Type 301, the embossed image is clear and well defined; with Type

Mechanical Properties of Welds in Types 201 and 202

Sample Weld*	Yield Strength	Tensile Strength	Elongation
Type 202, 0.052-in. sheet, inert-arc fusion welded			
XA	58,000 psi.	108,000 psi.	53%
WA	58,000	110,000	54
XB	48,000	106,000	59
WB	46,000	102,000	55
Type 202, 0.052-in. sheet, inert-arc and 308 filler wire			
XA	62,000	116,000	59
WA	66,000	117,000	58
XB	46,000	107,000	56
WB	47,000	101,000	41
Type 202, 0.014-in. sheet, Type 308 coated electrode			
WA	56,000	103,000	53
XB	52,000	97,000	28
Type 201, 0.5-in. plate, Type 201 electrode			
Weld metal	63,600	101,800	48

* X — Weld across grain
W — Weld with grain
A — Weld length of test specimen
B — Weld across test specimen

201, however, some clarity is lost in the deepest areas and the embossing die must be cut deeper to obtain the necessary definition. The same loss of clarity was found in wheel cover embossing but was easily overcome by increasing depth of punch and ram force.

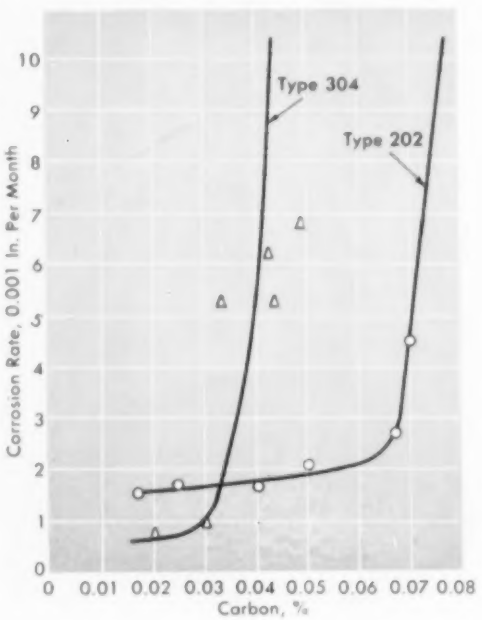
Limited production of steels requiring special handling always creates some difficulty if only because of the usual resistance to change of production personnel. Minor variations from heat to heat also tend to diminish as production increases. To date, the most extensive production changes have occurred in the annealing and pickling of the 200 series. Annealing temperatures now used for 300 series stainless cause more rapid scaling on the 200 series steels. For this reason annealing temperatures have been reduced 50 to 100° F. to reduce the scaling. Cold worked material should be annealed at 1850 to 1950° F. With this lower temperature anneal, 200 and 300 steels can be given the same pickling treatments. To prevent any possibility of overpickling in a nitric-hydrofluoric bath, hydrofluoric concentration can be decreased and pickling temperature lowered 10 to 20° F.

The Cr-Ni-Mn steels have much the same welding characteristics as the Cr-Ni grades with one major advantage — a reduced tendency toward intergranular precipitation of chromium carbide. All welding techniques commonly used for stainless steels have been investigated and the Cr-Ni-Mn steels can be used interchangeably with Cr-Ni steels. When filler wire or electrodes are used, they can be of either conventional analyses or the Cr-Ni-Mn analysis which matches the base composition.

The new stainless steels resist sensitization better than the Cr-Ni steels of similar carbon content. This provides an extra factor of safety for those fabricators who are only mildly concerned by intergranular precipitation — that is, those who do not use either solution annealing after welding or the extra-low-carbon grades at present. One example is transportation equipment which requires extensive welding but is exposed only to the corrosive attack of industrial atmospheres. Although there has not been any official recognition of an extra-low-carbon Cr-Ni-Mn steel, the maximum carbon limit to prevent short-time sensitization is twice as high for these steels as for the higher-nickel alloys.

Stress-corrosion tests have been made in boiling 42% magnesium chloride solution and indicate that chromium-nickel-manganese steels are about as susceptible to stress-corrosion as

Effect of Carbon Content on Nitric Acid Corrosion Resistance of Sensitized Types 202 and 304



Only a Slight Change in the Embossing Die Used for These Burner Supports Was Necessary When the Manufacturer Switched From Type 301 to Type 201 Stainless Steel. Embossing operation shown below

the chromium-nickel Type 301 and 302. Therefore, it is necessary to use the same precautions. Since stresses of this type usually originate in the fabrication or welding equipment, the unstabilized Types 201 and 202 should be given a final solution anneal. Stabilized grades in the 300 series can be given a stress-relief anneal which is performed at lower temperatures.

Not a single unsuccessful application of Cr-Ni-Mn steels has yet been discovered and many estimates place eventual use of these steels at 75 to 80% of the applications presently using Types 301 and 302. The slightly lower corrosion resistance of these steels may limit their application where resistance to pitting from certain chloride compounds is needed or in other places where the use of Types 301 and 302 is marginal. The general recommendation is to use Type 201 in existing Type 301 applications, Type 202 for Type 302; if Type 304 is required by service conditions, do not use the Cr-Ni-Mn grades.

A number of fabricators have been impressed by the efforts of the stainless steel producers to alleviate the current shortage of nickel by establishing the low-nickel grades. They have cooperated freely in the trial applications of these steels without the feelings of resentment which surrounded the substitution of straight chromium steels for the chromium-nickel grades during emergencies. Of concern to those who foresee continued nickel shortages is the customer acceptance of the Cr-Ni-Mn steels particularly where 18-8 has been established as standard and specified as such. For this reason, it is felt important by some that Types 201 and 202 stainless be recognized as a "new family of stainless steels" and not merely emergency substitutes for 18-8. The best estimate of the value of these new steels can perhaps be found in the belief of a number of persons that production of Types 301 and 302 could, if necessary, be stopped without any major effects.

Gating and Risering of Investment Castings

*By C. M. ADAMS**

Gates and risers for investment castings must be designed as if the mold were made from sand and well insulated. (E 22, E 15)

TO PRODUCE a sound casting economically, the metal must be introduced properly into the mold cavity and there must be some method of compensating for the shrinkage which inevitably accompanies solidification. This can only be done with a suitable system of gates and risers. Much of the elementary information concerning gates and risers has been gained from studies of conventional sand castings. Fortunately the fundamental requirements are so general that most of the principles may readily be transposed to investment castings using hot molds.

A riser is nothing more than a reservoir of liquid metal situated so as to compensate shrinkage during solidification of a casting. To function properly, a riser must remain liquid longer than the casting and must contain enough "extra" liquid metal to feed the casting. Since the riser is usually surrounded by the same mold material as the casting, solidification occurs at comparable rates in the casting and the riser. Consequently, the riser must be thermally and physically larger than the casting unless some artificial technique is used to preserve or generate heat in the riser.

In recent years the quantitative relationships governing minimum riser dimensions have been fairly well established and the results are typified by Fig. 1 which summarizes dimensional requirements of blind risers for steel castings. Both size and shape are taken into account through the use of volumes and surface areas of casting and riser. "Surface areas" are the areas of the casting or riser in contact with the mold. One of the curves has been calculated from experimental information and the other has been derived theoretically. They may be regarded as a map and are most easily used as a "go, no-go" criterion. First, the riser dimensions are estimated on the basis of experience. Second, areas and volumes are calculated and the corresponding point located on Fig. 1. If the point falls above the curve the riser is too small; if the point falls far below the curve, the riser is uneconomically large. A properly dimensioned riser will correspond to a point slightly above the curve.

Although this is the most precise method for dimensioning risers, it is cumbersome because of the necessity for calculating surface areas. There are approximate rules which are adequate for most investment applications. Consider that the riser is blind and its shape more or less fixed as a circular cylinder whose height equals 1 to 1.5 times its diameter. The riser diameter must be at least three times the section size of the casting if the casting is a plate, 1.5 times the section size if the casting is a bar and 1.1 times if the casting is a cube, sphere or similar chunky object.

The riser may be situated above or beside the casting and will not always be in direct contact with the casting. The dimensional requirements of the connection between the riser and the casting need never be more than two-thirds the diameter of the riser. If the layer of mold material between the riser and the casting is quite thin, the connection may be smaller but never less than one-fourth the diameter of the riser.

As to location of risers, the requirements are more simply stated than executed; risers should be located at or near the points of the casting which will be last to solidify. The surest way to locate these points is to radiograph an unrisered casting. If, at any time during solidification of a casting, there are two distinct zones which are

*Assistant Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. This article is based on a paper presented at a meeting of the Investment Casting Institute.

liquid separated by a zone which has solidified, two risers will be required.

Another consideration in location of risers is the distance which a riser can feed a uniform section. Although there is no quantitative information regarding feeding distance in hot molds, several conditions are clear:

1. Feeding distance in a uniform section is greater the hotter the mold.

2. An extremely thin section is probably impossible to feed, but the shrinkage is of such small magnitude that it cannot be detected.

3. A slight amount of taper in the design of a section will usually eliminate shrinkage in an investment casting, if feed material is available at the large end of the section.

4. Any temperature gradients existing in the mold at the time of pouring can eliminate or aggravate shrinkage in uniform sections. Obviously the riser should be placed at the hot end of such a section.

Anything that decreases the rate of solidification in the riser or increases it in the casting improves riser efficiency. Fewer such devices are adaptable to hot mold processes than to other casting techniques. Metal chills and moldable exothermic or insulating materials are impractical if not impossible to apply to investment procedures. However, certain benefits may be realized from judicious geometric arrangements of castings and risers in the molds. For example, it is not usually necessary to place the riser in direct contact with the casting because a connection between the two of considerably smaller cross section than the riser can be used. If the section of molding material between the casting and the riser is half the diameter of the riser or less, it will quickly become saturated with heat and solidification will be retarded in both the riser and the casting. In general, the effect on the riser will be relatively greater than on the casting, and riser efficiency will increase. The benefit of this arrangement is greater the thinner the wall of refractory separating casting from riser. There are, of course, practical limitations to this technique.

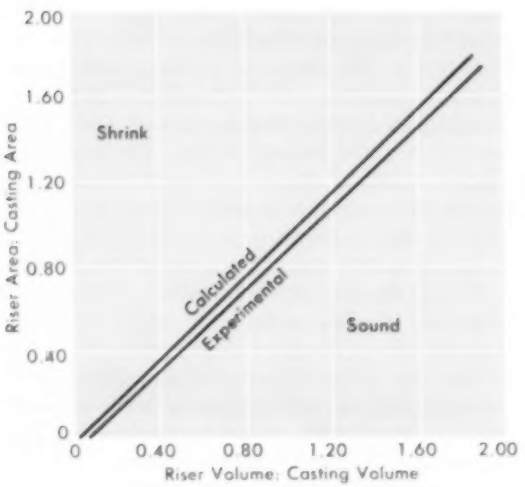


Fig. 1 – Relation Between Blind Riser Dimensions and Casting Dimensions Necessary to Produce Sound Castings

Advantage should be taken of any thermal gradients in the mold prior to pouring. As soon as the mold is removed from the furnace, it loses heat by radiation. Since the molding material is a fairly poor conductor of heat, appreciable temperature gradients quickly develop with the central region of the mold being, of course, hotter than the exterior. The riser should be located in the hottest part of the mold. The importance of this can be emphasized by a brief consideration of the effect of mold temperature on solidification rate. The time required for a given section to solidify is inversely proportional to the square of the difference between the freezing temperature of the metal and the initial temperature of the mold, other things being equal. Thus a particular section of a stainless steel casting would take 25% longer to freeze in a mold at 1800° F. than at 1700° F. By arranging several castings around a central riser as close to it as possible, the riser is located in the hottest part of the mold and the heat from the castings helps keep it liquid.

Where an open riser is employed, some attention should be given the radiant heat loss from the exposed surface of the riser. Some study has been given to this problem in connection with risering sand castings and the results are applicable to investment castings as well. Heating the mold has the same effect as insulating the sidewalls of the riser since both retard heat flow into the wall. Of the total heat which leaves an open riser during solidification, a certain percentage is radiated to the surroundings. Typical values are shown in Fig. 2. The higher the melting temperature of the metal and the hotter the mold, the more heat is lost by radiation. Sometimes half the metal in the riser may be wasted due to top losses. The use of any powdered refractory on open risers will greatly improve riser efficiency, particularly in casting high-melting alloys.

A gating system is inevitably a compromise

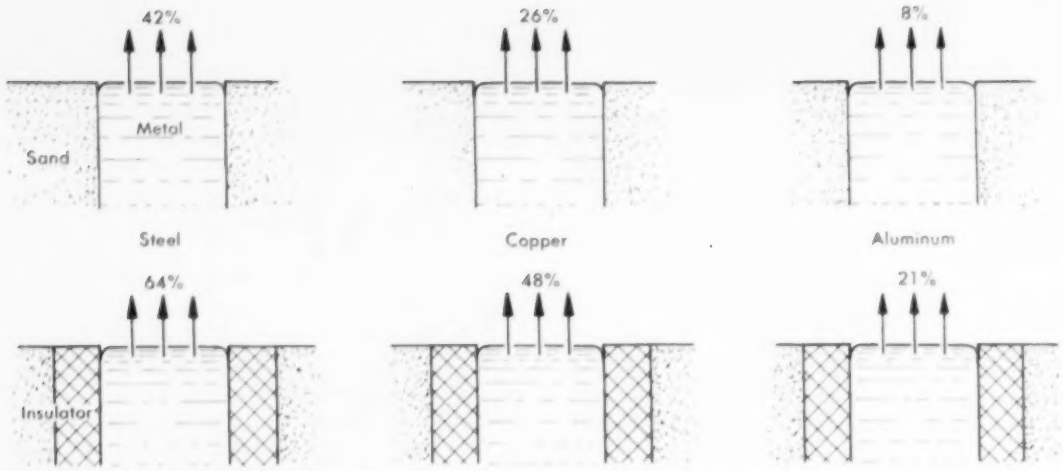


Fig. 2 – Effect of Insulated Sidewalls of Risers on Surface Radiation Losses

between a perfect and an economic fluid flow system for conducting liquid metal into the mold cavity. The rules are not at all distinct and are founded upon some fairly shaky concepts. Some valuable work has been done in recent years, but it has been largely based upon a few preconceived ideas as to what the gating system should or should not accomplish. However, as a result of recent work, published and unpublished, it seems safe to set forth those few important features of an ideal gating system upon which most investigators agree:

1. The rate at which the mold is filled should be controlled by the gating system, not the man pouring the metal. This is usually accomplished by the use of a fairly definite choke in the system, at or near the base of the sprue so that the sprue may be kept full at all times. Under these conditions, flow is more or less continuous, and surging or hesitation (which can cause laps or seams) is avoided. The cross-sectional area of the choke is smaller than any other section of the total flow path.

2. The system should be designed to minimize aspiration of air or cavitation of the flow stream, either of which will lead to entrapped gas or inclusions. The major weapon here is the tapered sprue; it is impossible to maintain a straight sprue full of liquid metal because the pressure in the flow stream is less than atmospheric. A tapered sprue operates at positive gage pressure throughout. The taper should be such that the cross-sectional area at the top equals twice that at the bottom. If the sprue is very tall, more taper might be required. Ordinarily the bottom of the sprue is the choke.

3. The system should incorporate devices which take the kinetic energy out of the flow stream at or near the bottom of the sprue. An abrupt enlargement or a well causes this energy to be dissipated in the form of eddy currents and reduces turbulence.

4. Casting defects which can be traced to the gating system are frequently caused by the first metal which enters the sprue. During the early stages, the system is operating as a partially open channel and no control can be exerted over the flow pattern. A purely negative but sometimes fruitful device is a bypass into which the first metal flows before the casting begins to fill. In this way entrapped gas may be avoided.

5. There is some merit in the use of gates and sprues of rectangular cross section. A rectangular cross section offers a higher frictional resistance to flow than a circular cross section and metal can be delivered to the mold cavity at a higher volume rate of flow, but at relatively low velocity, which is very desirable.

6. To avoid excessive jetting, washing or gas entrapment *(a)* the ingate should not be of larger cross section than the casting, unless the casting is gated through a riser, *(b)* the cross-sectional area of the well should be more than twice the sum of the areas of all the ingates, and *(c)* the cross-sectional area of the choke should be less than the sum of the areas of the ingates.

7. Due to the impermeability of the mold, overflows or vents on the mold cavity itself may be necessary to avoid gas entrapment.

The above should be taken as indications of current thinking rather than as hard and fast rules. In spite of the attention given in the literature, a definite understanding of flow and pressure in gating systems still does not exist and some fairly spectacular departures from conventional gating may occur in the future.

Conversion Coatings for Titanium

*By P. D. MILLER, R. A. JEFFERYS and H. A. PRAY**

Both conversion and anodic coatings on titanium alloys hold lubricants efficiently and eliminate or reduce galling in forming operations and in applications involving metal-to-metal contact. (L.14, Ti)

TITANIUM and its alloys have a severe tendency to gall and seize when in moving contact with other metals. Since this restricts their utility and also causes some difficulty in forming operations, considerable effort has been directed toward the development of surface treatments that would eliminate or reduce galling.

Two methods of producing satisfactory surface properties have been developed; one is an electrochemical anodizing process and the second is a chemical immersion treatment. Both produce a crystalline coating which is tightly bonded to the titanium base and can be chemically removed without excessive loss of metal.

Both acidic and alkaline solutions were used to produce anodic coatings. The most satisfactory coatings were those obtained in a 5% NaOH solution operated at 205° F. with a current density of 50 amp. per sq. ft. for 20 min. Coated specimens were tested for galling under high pressure on a modified shaper. In these tests, a hardened steel ball was drawn back and forth over the specimens 25 strokes per min. at a load of 70 tons per sq.in. After 250 strokes only a smooth wear track was apparent on the coated surface whereas the uncoated surface galled on the first stroke. Molykote G, a mixture of molybdenum sulphide and grease, was used as a lubricant. Very promising results were also obtained with the coatings in wiredrawing tests.

Anodic coatings are probably as durable as the immersion, or conversion, coatings but the latter are more desirable from an economic, as well as operational, standpoint, so they have received more attention. Three chemical baths have been found to produce durable conversion coatings on titanium alloys.

*Battelle Memorial Institute, Columbus, Ohio. The research reported in this paper was done under Contract DA-33-019-ARD-215 for the Office, Chief of Ordnance, under the sponsorship of Watertown Arsenal.

Table I – Conversion Coating Baths for Titanium Alloys

Immersion Bath		Temp.	pH	Coating Time	Alloys Coated
No.	Composition				
1	50 g. per l. $Na_3Po_4 \cdot 12\,H_2O$ 20 g. per l. $KF \cdot 2H_2O$ 11.5 g. per l. HF solution*	185°F.	5.1 to 5.2	10 min.	Ti-75 A RC-55 RC-130 B
2	50 g. per l. $Na_3PO_4 \cdot 12\,H_2O$ 20 g. per l. $KF \cdot 2H_2O$ 26 g. per l. HF solution*	80	<1.0	1 to 2	Ti-75 A Ti-150 A RC-55 RC-130 A RC-130 B
3	40 g. per l. $Na_2B_4O_7 \cdot 10\,H_2O$ 18 g. per l. $KF \cdot 2H_2O$ 16 g. per l. HF solution*	185	6.3 to 6.6	20	Ti-75 A Ti-150 A RC-55 RC-130 A RC-130 B

*50.3% HF by weight.

Their compositions and coating procedure are shown in Table I, which indicates that a number of the titanium alloys have been treated successfully. Chemical analysis of the coating obtained from the high-temperature fluoride phosphate bath (Bath No. 1) shows the composition to be approximately 39% fluoride, 3% phosphate, 25% potassium and 17% titanium, indicating the formation of a potassium-titanium-fluoride complex. The coatings from the other solutions are similar in composition.

Both immersion time and pH are important. Dissolved titanium and the active fluoride ion make it impossible to use glass electrodes for pH measurements. Indicator paper and colorimetry were found to be the most satisfactory tools for measuring Baths No. 1 and No. 3 which are held in the 5 to 7 pH range. Bath No. 2 is quite acid and titrametric analysis of samples appears to offer the most practical method of control. It was found that if the bath was in the proper coating range, a 20-ml. sample in 100 ml. of water would neutralize 11.8 to 12.0 ml. of normal sodium hydroride using a phenolphthalein indicator.

Immersion time has an important effect on the coating thickness. In all three baths, a specific time is reached after which the coating weight remains essentially constant. In both of the fluoride-phosphate baths, a maximum coating weight is reached at some time prior to this equilibrium point. The maximum coating weight is obtained in about 2 min. in the low-temperature bath and in about 10 min. in the other two baths. Data relating immersion time to coating thickness are shown graphically in Fig. 1.

The effectiveness of the immersion and anodic coatings in cold drawing tubes and wires has been evaluated rather extensively because of the difficulties experienced by commercial fabricators. In the plug drawing of tubes with a suitable drawing lubricant the high-temperature fluoride-phosphate coating permitted successive draws with a maximum reduction of about 65%. After drawing, the coating was removed by a 30-sec. dip at room temperature in a hydrofluoric-nitric bath. This restored a smooth bright finish to the metal. The best drawing was obtained with a Ti-75 A alloy tube. In four passes, this tube was reduced 66.5% with only slight signs of galling on the fourth pass. These results are considerably superior to those of present commercial methods.

Extensive tests in wiredrawing were made using a laboratory drawbench on which pieces up to 22 ft. in length were processed. The immersion coatings improved the drawing properties of Ti-75 A considerably as shown in Table II. In one instance, as many as 17 passes were made for a total reduction of 94%. It should be

Fig. 1 – Weight of Conversion Coatings as a Function of Immersion Time

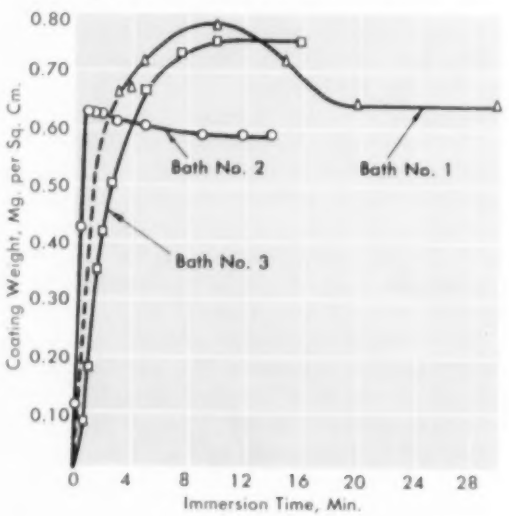


Table II – Wiredrawing of Titanium Using Immersion Coatings

Coating	Drawing Lubricant	% Total Reduction	No. of Passes	No. of Coats	Final Condition
Bare	Molykote G	—	0	—	Galled
Bare	Bonderlube	—	0	—	Galled
Bath No. 1	Molykote G	85.0	8	2	Smooth
Bath No. 2	Molykote G	94.0	17	7	Smooth
Bath No. 2	Bonderlube	68.3	7	3	Galled
Bath No. 2*	Molykote G	70.0	7	1	Smooth
Bath No. 3	Lacquer MoS_2	63.0	8	2	Smooth
Bath No. 3	Molykote G	63.0	8	3	Smooth

*Heat treated 1 hr. at 800° F.

Table III – High-Pressure Wear Tests on Coated RC-55 Alloy

Finish	Lubricant	No. of Strokes	Final Condition
Bare	None	1	Galled
Bare	Molykote G	1	Galled
Bath No. 1	Machine oil	250	Smooth wear track
Bath No. 1	Machine oil	375	Worn thin
Bath No. 1	Machine oil	500	Smooth wear track
Bath No. 1	Molykote G	500	Smooth wear track

noted that recoating was necessary after about three passes were made. No annealing was required for any of the specimens listed.

The wire and tube drawing tests show very well the usefulness of the coatings for this application. There is little reason to doubt that forming operations such as cupping and deep drawing will also be aided by these coatings. In addition, costs of operation should not be great because the coatings are easy to apply and remove.

Two kinds of wear tests were used to evaluate the coatings: *(a)* reciprocating wear which simulates the sliding motion of many parts, and *(b)* high-speed rotary-wear tests which introduce significant shearing forces and a different type motion. As with the anodic-coated specimens, the immersion-coated samples were tested under high pressure (70 tons per sq.in.) on the modified shaper. The coatings appeared to form a smooth, highly polished surface layer between the ball and the base metal and markedly improved the response of RC-55 to the high-pressure contact of moving steel, as shown in Table III.

Another type of machine used for some of these tests reciprocated 23 times per minute using a 4½-in. stroke and flat button specimens. When a failure occurred, the specimen seized to the wear plate and automatically terminated the test. This test gives a reasonable indication of the durability under conditions of slow speed and heavy loads.

Four types of specimens (⅜-in. buttons lapped to optical flatness) were tested against four types of wear plates at loads of 200 to 2500 psi. All tests were made under S.A.E. No. 30 machine oil. The four types of specimens were: bare, air-oxidized, immersion-coated, and air-oxidized immersion-coated 75 A alloy. The four types of wear plates employed were: hardened steel, bare titanium, immersion-coated titanium, and air-oxidized immersion-coated titanium. All air oxidation was done at 800° F. for 2 to 5 hr. Neither an immersion coating nor air oxidation alone causes a significant increase in wear characteristics, but it is the combination of the two treatments in proper sequence which gives the markedly increased resistance shown in Table IV. It should be noted that the pieces are first chemically treated and then air oxidized.

Because of the slight improvement in wear obtained by the air oxidation of bare titanium, it was thought that formation of TiO_2 might be important in determining the wear characteristics. Since the data also showed that the immersion coatings were more effective for reciprocating wear in the button test when followed

Table IV – Reciprocating Wear Tests

Type of Coating on Wear Surface*		800° F. Oxidation, Hr.	Load, Psi.	No. of Strokes to Galling
Titanium Button	Wear Plate			
Bare	Steel	0	400	1
Oxidized	Steel	2	2500	4500
Bath No. 1	Steel	0	400	15
Bath No. 1	Steel	3	2500	1,018,298†
Bath No. 1	Steel	5	2500	1,156,898†
Bath No. 3	Steel	1	2500	79,581
Bare	Bare titanium	0	600	4
Bath No. 1	Bare titanium	0	600	8
Bath No. 1	Bath No. 1	0	550	17

*All tests were made under S.A.E. No. 30 machine oil.
†Tests were stopped before galling occurred.

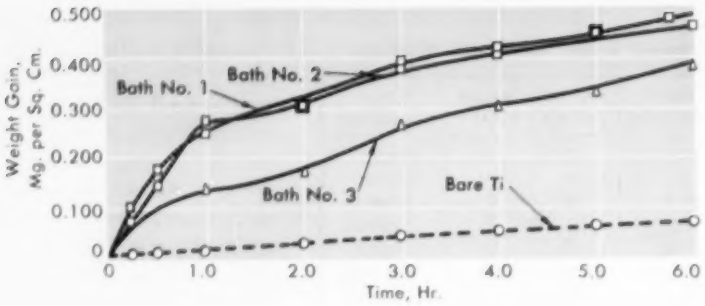


Fig. 2 – Oxidation of Coated and Uncoated Ti-75 A at 800° F.

by heating in air, the effect of the immersion coatings on the rate of oxidation of the titanium was investigated. The immersion coatings significantly increase the oxidation rate of titanium, as shown in Fig. 2. From metallographic and X-ray examination, it was concluded that the increased wear resistance is brought about by the formation of a layer of TiO_2 on the titanium. Photomicrographs and physical property data also indicate that the original fluoride coating is retained above the TiO_2 layer which is adjacent to the metal.

It is important to note that the temperatures at which the immersion coatings increase the oxidation rate and improve the wear are below temperatures which change the structural characteristics of the metal.

High-speed rotary wear tests were conducted on a machine which forced two cylindrical button-type specimens against a lapped steel disk under pressures varying from 50 to 800 psi. The disk and specimens were contra-rotated, each at a linear speed of 910 ft. per min. The high relative speed (1820 ft. per min.) resulted in high shearing stresses at the points of contact. Coefficient-of-friction measurements were made between the specimens and the disk by a planetary gear dynamometer.

At pressures as low as 200 psi., untreated titanium seized instantly on the steel. Immersion coatings and air-oxidized immersion coatings improved the wear to some extent but no runs of more than 7 hr. were obtained in the preliminary tests. Lack of proper lubrication under these high stresses probably caused the failures so an attempt was made to develop a satisfactory method of lubrication. This was done by incorporating one part of molybdenum disulphide in two parts of a thermosetting epon-phenolic resin (unpigmented Synthetasine 100). This mixture was applied to the specimen, air dried 6 to 12 hr. and cured for 8 to 12 hr. at 300° F. The resin layer was then burnished to a hard ebony-black surface which was 0.002 to 0.005 in. thick. The running time was increased considerably with the combinations of immersion coating and resin, as shown in Table V.

The immersion coating apparently improves the resin bond. Air oxidation of the immersion coating is not necessary to effect this improvement. Other tests on flat panels showed that an improvement in the adhesion of ordinary paint or lacquer to titanium was furnished by these conversion coatings. The resin bonding of other metals to titanium should also be facilitated by these surface treatments.

Table V – High-Speed Rotary Wear Tests on Titanium

Finish	Oxidation at 800° F.	Resin*	Load	Running Time	Coefficient of Friction†	Final Condition
Bare	0 hr.	No	200 psi.	0 hr.	—	Galled instantly
Bath No. 1	0	No	400	0.01	—	Galled
Bath No. 1	5	No	400	3.6	0.047	Galled
Bath No. 1	19.5	No	600	6.7	0.014	Galled
Bare	0	Yes	600	0.67	—	Galled
Bare	2	Yes	600	0.73	—	Galled
Bath No. 1	2	Yes	600-800	199.0	0.017	Undamaged
Bath No. 1	2	Yes	600	161.5	0.062	Undamaged
Bath No. 2	2	Yes	600-800	225.0	0.072	Undamaged
Bath No. 2	0	Yes	800	273.0	0.069	Undamaged

*One part molybdenum sulphide in two parts epon-phenolic resin.
†Average. All tests were run under S.A.E. No. 30 oil.

Delayed Centerline Cracking of Warm Rolled Titanium Alloy Ti-150 A

Delayed Cracking of Rolled Ti-150 A

*By HAROLD BERNSTEIN**

Centerline cracking of warm rolled Ti-150 A which occurs after the alloy has cooled to room temperature can be eliminated by a stress-relieving treatment or by proper edge preparation. (F 23, J. 1, Ti)

DURING an investigation of stress-relieving treatments for commercial titanium alloys, specimens were prepared by cold rolling ¾-in. plate to 0.15-in. sheet. In this process the Ti-150 A alloy developed severe edge cracking and it was necessary to preheat to obtain satisfactory test strips. Some time after cooling to room temperature, the strips began to crack at the ends. In some instances the crack progressed until the sample separated into two pieces.

In order to determine whether a critical amount of reduction was necessary for the delayed cracking, specimens ¾ × 1 × 3 in. were warm rolled to various thicknesses. They were preheated at 930° F. for 20 min. and reheated for 3 min. after four passes (0.010 in. reduction per pass). Total reductions ranged from 12 to 51%. The hardness varied from C-36 as received to C-41 after 51% reduction.

Cracking began approximately 2 hr. after rolling. After 24 hr., all specimens with reductions between 12 and 40% had cracked 90% of their lengths. The sample which had been reduced 44% had only a slight end crack, yet the one with 48% reduction had cracked through ¾ of its length. The specimen that had been worked the most – 51% reduction – was intact. One week later, the sample reduced 44% was unchanged but all the others had cracked over 90% of the strip length. Evidently, amount of reduction is not critical.

The cracks started at the transverse edge of the rolled strip near the centerline. At first, this was considered a sign of centerline weakness caused by segregation or impurities. After examining a large number of cracked specimens, however, it was observed that the cracks started in irregularities such as folds or laps near or at the ends of the rolled strips. They started more often on the flat sides of the strip than at the transverse edges. To check this, the ends of warm rolled strip were cut off immediately after rolling and no cracking occurred. Thus, it appears that crack initiation is due in part to high residual stresses in the strip ends.

All of the specimens described above were cut in the longitudinal direction of the ¾-in. plate

*Metallurgist, U.S. Naval Gun Factory, Washington, D.C.

and were rolled in the same direction. To check on the effect of directionality, two specimens 1½ × 6 in. were cut in the transverse direction and were rolled parallel to the long dimension (in effect, cross rolled) and again there was no cracking.

Delayed cracking in titanium alloys is generally attributed to the presence of a strain-aging solute such as hydrogen. While the obvious remedy is to vacuum anneal, this may not be practical and other means of preventing delayed cracking must be utilized. Cropping the ends of freshly rolled material is one method. Another is the elimination of the residual stresses by a suitable heat treatment immediately after rolling.

In the stress-relief investigation previously mentioned, a special fixture was developed in which strips of the various alloys were beam-loaded to their respective yield strengths and then place in a furnace for 1 hr. If the stress-

Book Review...

Fatigue in Theory and Practice

*Reviewed by PAUL P. MOZLEY**

FATIGUE, by T. J. Dolan, B. J. Lazan and O. J. Horger. American Society for Metals, Cleveland, 1954, 121 p., $3.

STRENGTH AND RESISTANCE OF METALS, by John M. Lessells, John Wiley & Sons, Inc., New York, 1954, 450 p., $10.

The need for information on fatigue and fatigue failures has become increasingly urgent with the greater emphasis on the ratio of strength to weight of metal structures. When weight is not an important consideration, individual components are made sufficiently bigger and heavier than is theoretically necessary so that fatigue life need not be considered. In aircraft, however, every extra ounce of structure is costly and more specific knowledge of fatigue would permit more efficient aircraft design. Other industries have also realized that it costs money to move unnecessary weight and are re-examining the safety factors used in design and reducing them wherever possible.

Unfortunately it is not yet possible to analyze a complex mechanism and predict a definite life when it is to be exposed to fluctuating stresses. Fatigue failures follow a statistical pattern and there are usually too few data available to get an accurate indication of the distribution of service life to be expected.

"Fatigue" is based on papers presented during the National Metal Congress and covers some of the more recent theories of fatigue. It is primarily devoted to scientific discussion and although there are a few practical illustrations it is not intended as an engineering guide for designers.

The subject is approached from three levels of observation – large-scale effects visible to the eye, an intermediate range requiring X-ray or microscopic study, and the atomic level which is entirely theoretical in nature. Most of the discus-

*Staff Metallurgist, Lockheed Aircraft Corp., Burbank, Calif.

relieving treatment is 100% effective, the strip will take a permanent set and there will be no spring-back when the load is removed. If none of the stress is relieved, the strip will assume its original shape when unloaded. Efficiency of stress-relief is calculated from the ratio of permanent set to the original elastic deflection.

For Ti-150 A, 1 hr. at 800° F. followed by air cooling relieved 92% of the residual stress. A longer time or slightly higher temperature is recommended if it is necessary to remove all stress for very precise dimensional control. At lower temperatures, the efficiency of stress-relief decreases; at 600° F., it was 47%, at 400° F., 22%. Values for two other commercial titanium alloys were also determined. Residual stress was completely relieved in RC-130 A in 1 hr. at 800° F.; at 600° F. efficiency was 55% and at 400° F., 40%. For alloy RC-130 B, the values were 90%, 40% and 30%, respectively.

sion deals with the first two although the theory of dislocations is briefly explained.

Under the discussion of large sections, a comparison is made of the results of tests of many small specimens versus a few or only one very large specimen. Since it is usually not possible to test many large specimens, it is helpful to realize that actually you are obtaining an average value for a large quantity of metal and that one may just as safely design around such results as to use those obtained from a large number of small specimens. Small specimens are apparently affected by minor defects such as small inclusions while large parts in a test rarely break in the area where the minor defects are found.

Since parts are rarely stressed uniformly, procedures are shown for obtaining design criteria for complex conditions. The subject of size effect and the necessity of testing only a few large specimens indicate that there will always be some uncertainty regarding the validity of the spread of fatigue strengths to be expected of large sections.

If results on small specimens are known and a few tests are made on extremely large specimens then the intermediate values can be safely estimated by assuming that the functions are straight lines. It would seem that this might bear further study although a number of examples appear to justify that conclusion. It is surprising to learn that in large parts wide differences in metal structure have little effect on the useful fatigue life. This is very different from the results in small specimens or experience with smaller parts. Even grain flow, which we have always held in a sort of reverence, has been found to have little effect on the life of large parts.

Some attention is paid to cumulative damage by fluctuating loads and the relation of previous stress history to fatigue life. All this may be greatly affected by microstructure, grain size, temperature or in fact almost any change in either the material or the environment, especially in relatively small parts.

In contrast, the book by Lessells covers many properties of metals. It includes such subjects as elastic and plastic behavior in tension and compression, testing methods, residual stresses, the effects of temperature, hardness, impact, fracture, damping, wear and working stresses in addition to the section on fatigue. All these are discussed from an engineering rather than the theoretical viewpoint although sufficient theory is given to provide a basic understanding.

The section on fatigue in "Strength and Resistance of Metals" is very complete and includes a general discussion of practically every imaginable condition that would affect fatigue life. Among these are the effects of temperature, size, form, surface condition, surface protection and mechanical work. The information is clearly presented with a large number of graphs, sketches and photographs to illustrate the subject. To make the test still more useful, actual problems and their solutions are given.

The two books cannot be compared easily since they are written with entirely different purposes in view. They fulfill different functions in the study and understanding of fatigue; one presents the theoretical aspects while the other presents the practical engineering viewpoint. If you want a very complete text on the engineering behavior of metals, the book by Lessells is excellent. If you are interested in fundamental theories of fatigue, "Fatigue" should be an interesting and informative work.

William Park Woodside and His Philosophy of Research

*By ALVIN J. HERZIG**

Positive information about a new metal and its rapid introduction into commercial products can best be achieved by two groups of men working together and supplementing each other – one skilled workmen, the other scientific researchers – who face squarely and even magnify any shortcomings of a new material or method. (A 9)

It is not only the privilege of a Woodside lecturer but also my duty as one of his closest associates to speak somewhat more intimately to this meeting of his friends than might ordinarily be appropriate in an honorary lecture. It is a duty because any technical accomplishments to which I can refer are products of an organization heavily endowed with what might be called "The Woodside Philosophy of Investigation".

Its basic concept is simple. It is that the skilled workman and the professional worker should be of mutual inspiration and assistance. To achieve such cooperation in his staff, Mr. Woodside used every organizational device and political tactic gathered from his long experience. From him, each group could obtain a good deal of freedom – although neither could be certain when they were near the limit of his tolerance! Mr. Woodside succeeded in making this philosophy operative at our laboratory. The *spirit* of research and investigation was extended to the entire personnel of his establishment. The *physical process* of investigation began at the level of instrument makers rather than at a later stage of interpretation of tests by supervisors.

As is common among men of his generation who had missed the opportunity of university training, Mr. Woodside tended to overrate the value of an academic degree. On the other hand, he never set aside the intuitive judgment and experience of skilled workmen without the same careful appraisal which was accorded to the advice of his professional associates. He was optimistic about the outcome of any technical investigation if the objective was a salable product. He displayed an air of confidence which comes only with success.

The two strongest convictions which he developed to implement his philosophy were:

1. There are highly practical aspects of organized investigation most efficiently conducted by practical people.

2. The abstract, technical approach of the professional investigator, when employed by competent professional people and properly administered, could also yield practical results.

Mr. Woodside's metallurgical career began at the forge fire and anvil. It seems to me to be true that among solid-state physicists, chemists, physical metallurgists, and blacksmiths, the blacksmith alone has the opportunity to discover and experience the intrinsic character of the metallic state. This is the type of man who set out to establish the character of research for the molybdenum industry in 1931. His program was described – not by a list of metallurgical principles to be studied – but by a list of the uses of metal which he thought could be improved by the use of alloys. If there was limited back-

*President, Climax Molybdenum Co. of Michigan. Excerpts from the 13th Woodside Lecture before Detroit Chapter ASM.

ground in academic theory, there was an abundance of inquisitiveness, resourcefulness, enthusiasm and spirit. How this combination found itself during the early years of operations is worthy of brief review.

Mr. Woodside animated – personalized, rather – his knowledge of materials and processes. Whatever metallurgical subject you brought up, he immediately mentioned the name and knowledge of a man who had had experience in that field. To him, this was more than a memory device; to him, the man's name and the composition or process were synonymous. Within our own organization he used this technique in subtle ways: When your stock was high, you would hear of "Timmons' Metal" or the "Blackett Process". On the other hand, if it was your misfortune to have sponsored a turkey, you would hear such designations as "Victorite" or "Parkite". Less subtle was the naming of a particularly fruitless project as "Herzig's Folly".

If there were any areas in the field of metallurgy which were more intriguing to him than others, these were carburizing steels, and the tool and die steels. In the carburizing process, he found his fortune; in toolsteels, which he treated with reverence, he found his avocation.

On carburizing steels, and over a long period of years, Mr. Woodside collaborated with Bunny Dawe, Dale Bower, Joe Bourg, Harry McQuaid, Mike Watson, John Wandersee, John Robinson, Fred Griffiths, John Abbot, Bob Atkinson, Bill Harris, Tom Hardy, Tony Hoensheid and Arvid Wadson, not only in the development of nickel-molybdenum carburizing steels but also in the formulation and production of widely used, solid carburizing compounds. He possessed an encyclopedic knowledge of the recommended practices for the various carburizing steels, and through long experience had first-hand knowledge of the desired properties in many parts for which they are used.

On the subject of tool and die steels, he held a romantic point of view. To him tools were instruments potentially the master of all other materials. When he examined a cutter, a tool bit, a chisel, or a die, his attitude was that of one who not only appreciated the development of this capability in metals, but who also was sympathetic with any deficiency therein. He derived from this attitude a dramatic story of man's progress toward a civilized state.

He sought out avidly such men as Joe Emmons, Clayt Gorham, Tom McGraw, Charlie Herty, Norm Stotz, Bill Finkl, Jack Succop, Walt Breeler, Harry Askew, Murray Campbell, Oscar Harder, Alex Lumsden, John Findlater, and heard from them their story about red hardness in steel. He responded with his knowledge of the capacity of molybdenum to generate this property in ferrous alloys. He directed work on new toolsteel compositions; on their preferred heat treatment; and on the collection of evidence that molybdenum high speed steels could best cure our country's tungsten deficiency. He squarely faced the issue of decarburization in molybdenum high speed steel, and proceeded on the basis that the best solution would be obtained at the earliest possible date by emphasizing and exaggerating rather than minimizing this shortcoming of the materials and furnaces of the 1920's and 1930's.

One cannot evaluate quantitatively the effect that Mr. Woodside's efforts played in winning the strong place molybdenum now has as an alloying element in carburizing steel and in tool and die steels, but they were undoubtedly of a very high order.

The establishment of the laboratory in Detroit and the shakedown of the staff and equipment were undoubtedly the happiest of Mr. Woodside's research assignments. As each new piece of apparatus was set up, he was on hand to watch the trial run and to learn as much as he could about its operation. He seemed to be fascinated rather than discouraged by any inexperience of the younger staff members—this was an opportunity for them to learn from him. The immediate objectives were to build up a backlog of data on the behavior of molybdenum in those uses where it was already being applied on a commercial basis, and to explore the many hunches he and his friends had about its potentialities. Our potential customers literally overwhelmed us; everyone was anxious to cooperate and gave samples and experience freely to speed us along.

These were the days of physical property charts and critical point determinations and we produced our share of them, using commercially made bars as well as steels made in our laboratory furnaces. This was the period when abnormality and grain-size determinations by the McQuaid-Ehn test were still the new approach to a better understanding of carburizing steels and their behavior. We also worked with others, principally C. H. Wills, F. E. McCleary, and Walter Hildorf, who extended these concepts to compositions beyond the carbon range of the carburizing grades.

Laboratory of Climax Molybdenum Co. of Michigan as It Was Established in 1931. In 1936 the work moved into much larger and more elegant quarters. A story about this new building in Metal Progress *for March 1937 commented on its ultra-modern exterior and on its air-conditioned interior*

We worked on John Robinson's chilled iron plow shares, McElwee's pearlitic malleable iron, Jack Beaumont's malleable iron brake drums, J. Kent Smith's camshafts, Kissock's wear resistant steel, and Loeb's white iron. We tested Paul Snyder's Mn-Mo cast steel for railroad castings, and Ed Young's Cr-Mo cast steel for dipper teeth. We measured the effect of low temperatures on the impact strength of heat treated S.A.E. steels, investigated the effect of small amounts of aluminum and phosphorus on cast iron. We sought to pinpoint the specific effects of the various alloys when added to gray cast iron and we believe we were among the first to recognize the acicular constituent in superstrength cast iron, which depends on the presence of molybdenum.

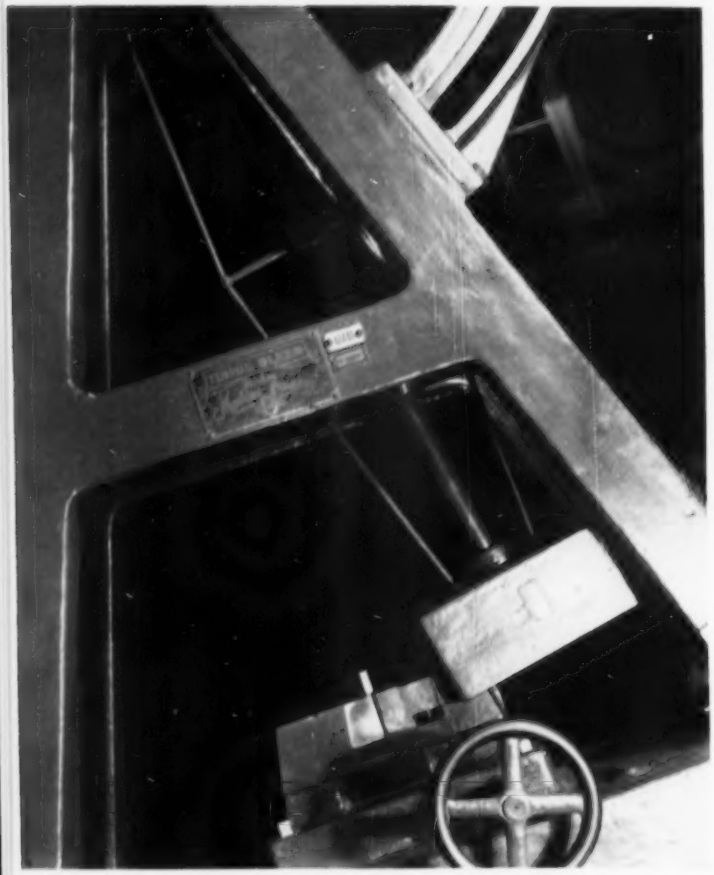
In all of these projects, we succeeded in accumulating positive information on which to base a future research program. Less successful were our attempts to produce carbon-free cutting tools, growth resistant cast iron through addition of tellurium, higher fatigue limit steels alloyed with beryllium and uranium, molybdenized surfaces on steel by cementation processes, and uniform dispersions of molybdenum in copper. Mr. Woodside said these efforts were "metallurgical slumming".

But by 1936, at the close of the formative period, we had learned that alloying in ferrous materials was a complex matter. We had found out that while no element could dominate the field, the place which our favorite metal could take was not necessarily a subordinate one of assisting other elements. It had various excellencies in its own right. We had confirmed the newly advanced idea that the classic theory of the hardening process did not explain many of the observed phenomena. Most important, we had learned that however small our own effort might be, compared with the vast amount of work which must be done in industry to achieve a new commercial specification, our contributions were welcome since they were technically sincere. Finally, we learned that we had a staff who had ideas on how to go about the big job that lay ahead.

The formative period was unavoidably a confused one. This did not dismay Mr. Woodside as it often did me. On complaining to him on one occasion that amid such confusion I could not tell where I was at, he replied, "Al, don't let that bother you. The only time you can be sure of where you are is when you're on the outside looking in."

Years of Confirmatory Work

The work which was done in the Detroit laboratory of Climax Molybdenum Co. of Michigan under Mr. Woodside's direction from these early



formative years up to his retirement in 1943 deserves accounting at more length than can be given in this portion of the lecture. This was a period of confirmation and conformance (harmonization?) wherein it was essential to bring the basic knowledge about molybdenum into phase with the rapidly changing philosophy of alloy steel and iron metallurgy.

The details are far too numerous and intricate for presentation, but they included a change in our conception of the steel hardening processes, the utilization of the new Jominy test for hardenability of steel, and the realization that the various alloying elements had desirable effects when used in combination. We studied intensively the reasons why molybdenum increased the creep resistance of steels – without finding the exact answer, it must be acknowledged – and the obscure causes of temper brittleness. We took a long and cautious look at the very practical yet exceedingly complex subject of the machinability of alloy steels and heat treatments that would promote this desirable property. Mention must also be made of the studies on high-strength cast iron.

Thus it was that, by the start of World War II, the potentialities of molybdenum in steel and cast iron were no longer obscure. In 1941 Mr. Woodside directed that, insofar as consistent with the maintenance of our technical position, we apply our acquired knowledge to ordnance production problems and to such researches as suggested by the wartime Office of Scientific Research and Development. In the work on small arms, we helped in the studies which eliminated 4% of "strategic" tungsten from the then standard specification. We worked on cast tank armor-plate compositions, cast tank track shoes, and the heat treatment of armor-piercing shot. We cooperated in the extensive testing program which resulted in the National Emergency Steel Specifications. Using techniques developed during our experimental production of massive molybdenum metal, we explored the possibility of producing ductile chromium-base alloys by vacuum melting and casting. We helped formulate shorter annealing cycles for the highly alloyed steels used in certain armament, and worked on the service problems attending the enforced substitution of molydenum high speed steels for the more conventional tungsten high speed steel.

This is the point to which in 1943 Mr. Woodside had brought his direct contributions in molybdenum research. He inaugurated the use of a molybdenum-containing steel in the American automobile industry at Studebaker in 1919. Starting in 1931 with an elementary concept for which the cut-and-try investigations of the 1920's had at best provided a shaky and insecure foundation, he had – through an educational and administrative effort in research – contributed greatly to a secure technical position for molybdenum as an alloying element in steel and cast iron. It is not too much to say that this was useful to his employers and to his country because it conformed with the new philosophy of alloys in steel and iron even at the moment when that philosophy was established. He had resisted technical prejudice whether for or against molybdenum, and he had confirmed his own convictions that progress in laboratory research required reciprocity between men who "know how" and men who "can do".

These, I believe, are the high spots in his research career. Quite apart from his role as a founder member of the American Society for Metals, it is proper that we should, as metal men, honor him for these substantial achievements.

Versatile Melting Equipment for Alloy Development

*By L. M. BIANCHI and A. J. SCHULTE**

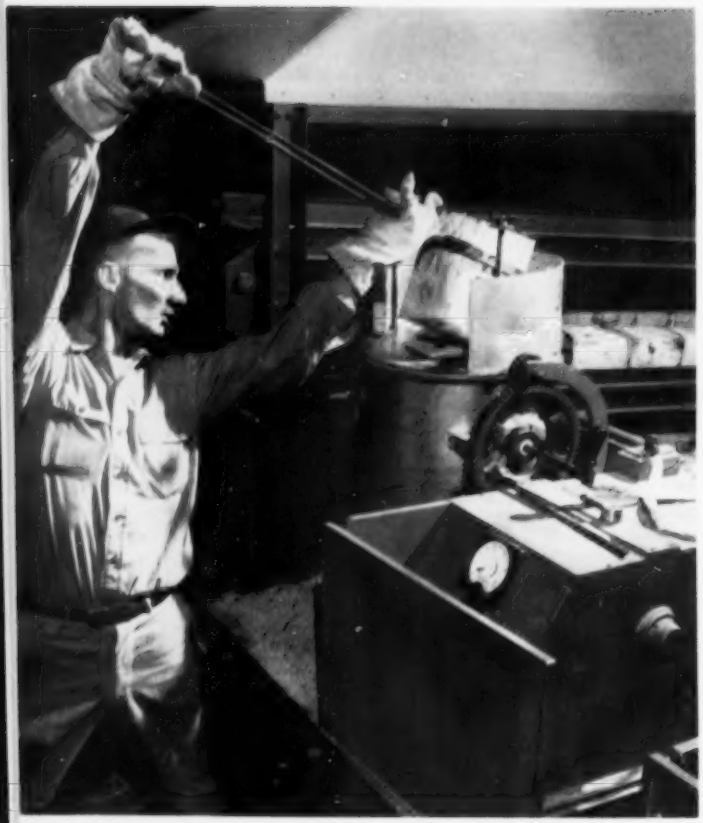
Melting equipment available at the new Westinghouse plant can produce heats ranging from laboratory size for preliminary investigation to production sizes for full-scale testing. (D general, E 10)

One of the most frustrating periods in an alloy development program is the time between successful completion of the laboratory investigation and proof of the results in full-scale production. To decrease this time lag between research discovery and industrial application, Westinghouse has built a completely integrated metallurgical facility at Blairsville, Pa., capable of handling both laboratory-scale studies and production-size pilot-plant evaluation of new alloys. Heats from 10 to 5000 lb. can be melted, cast, rolled and forged in commercial sizes. The equipment is necessarily varied and adaptable.

Since many of the new alloys, particularly the heat resisting materials, are used as precision investment castings, we have a complete commercial foundry. The furnaces are indirect-arc automatic rocking crucibles. The rocking and roll-over are actuated by hydraulic cylinders. Rocking decreases melt time and aids in stirring the metal bath and is synchronized with the roll-over in pouring. Each crucible is designed for melting under controlled atmosphere and gas pressure can be increased in the crucible just after the investing roll-over. The increased pressure will often fill thin sections in the mold that may not otherwise be filled. Other equipment includes a 20-kw. induction furnace and a Detroit rocking electric furnace. Both are designed to melt under controlled atmosphere.

Where surface finish and dimensional tolerances are not as precise as those required in the

*Materials Manufacturing Dept., Westinghouse Electric Corp., Blairsville, Pa.



Rock and Roll-Over Furnace Used For Investment Casting

investment molding process, castings may be produced in shell molds. At present we are producing commercial castings by the shell mold process and using the production experience to develop improved processing techniques. Melting equipment in this section of the Blairsville plant includes one 250-kw. two-stand induction unit and one 100-kw. two-stand and lift coil unit. The power supply for the 250-kw. unit is coupled to the furnace by pit contactors, thus permitting quick interchange of furnaces. Extra furnaces lined with various refractories are kept on a standby basis and employed as needed. The 100-kw. units are used for development heats of casting and ingot production. The melting units are equipped to produce carbon and high-alloy steels as well as copper and aluminum-base alloys for experimental and production requirements.

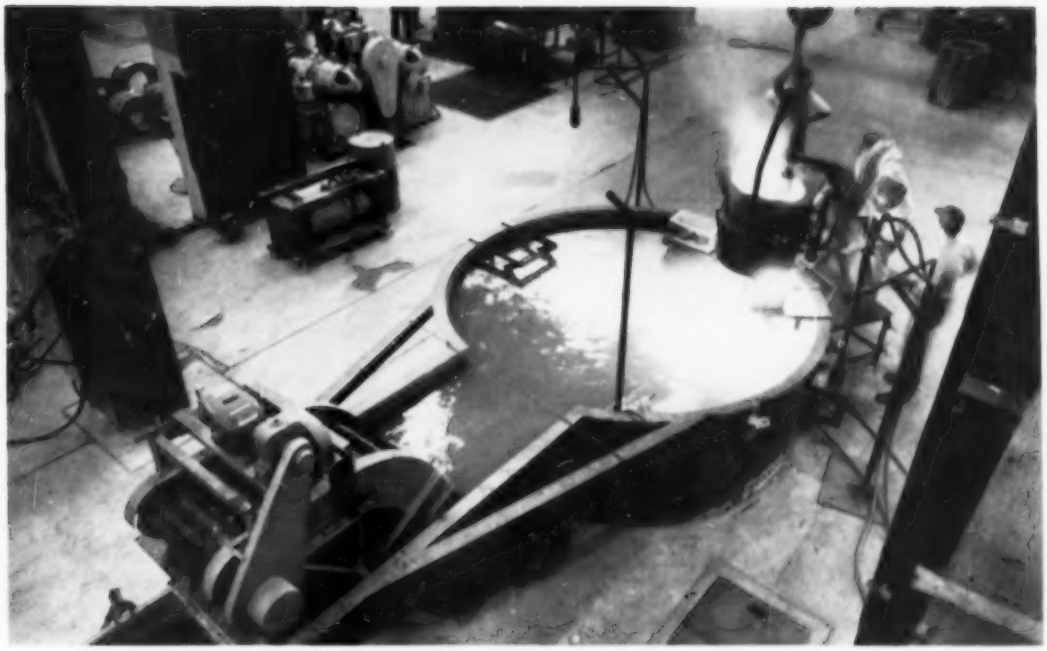
Ingots for the rolling and forging are produced in air and vacuum furnaces. Heats are air-melted in a two-stand 700-kw. induction furnace. The unit is designed to accommodate heats from 2000 to 6000 lb. Induction furnaces are coupled to the power supply by pit contactors, making it possible to interchange furnaces in a matter of minutes. The large furnaces not only offer the advantage of increased ingot size, but they also decrease considerably the expense of analysis that might otherwise be incurred with smaller heats.

Products from the 700-kw. installation range from 500 to 5000-lb. ingots of magnetic alloys, nonmagnetic high-strength alloys and high-temperature alloys. Melting and teeming can be done in air or controlled atmosphere. Highly oxidizable alloys are poured in ingot molds that have been thoroughly flushed with argon, and sealed to the bottom of the ladle. The argon atmosphere is maintained during the teem. Samples for analysis are taken during the middle of the teem and are kept in the argon chamber until solidified.

Vacuum Equipment

To meet the demands of the precision casting department a large shotting tank is installed in the 700-kw. melting section. The tank is 10 ft. in diameter and 12 ft. deep, is equipped with side-entering propellers for bath agitation, and contains a conveyer for continuous removal of shot. The large size of the tank will permit 3000-lb. pours.

Teeming an Ingot in an Argon Atmosphere



Shot Is Made by Pouring Melt Through a Perforated Mold Into Tank of Water

A few years ago, vacuum melting equipment was considered a laboratory curiosity rather than a production tool. Realizing that vacuum melting equipment was a necessity for exploiting new alloy development, Westinghouse installed a large vacuum furnace capable of melting either a 300 or 1000-lb. heat and a small 50 to 200-lb. vacuum furnace. The 1000-lb. furnace is in a 7-ft. diameter tank having ports which make the operation semicontinuous. The furnace is a tilt-pour type which uses one trunnion as a coaxial power lead. The pumping system consists of a 750-cu.ft. per min. Kinney pump and two KS-4000 diffusion-ejector pumps. They are capable of maintaining a pressure of 0.5 micron throughout the processing of a 300-lb. heat.

To increase the adaptability of the furnace as well as to assure the production of quality ingots, the following accessories were incorporated in the equipment: bridgebreaker, thermocouple assembly, a metal sampler, several sight ports, an addition hopper, an arc hot-topping arrangement, a hydrogen deoxidation rod, a radiation shield and a deposit-free sight port.

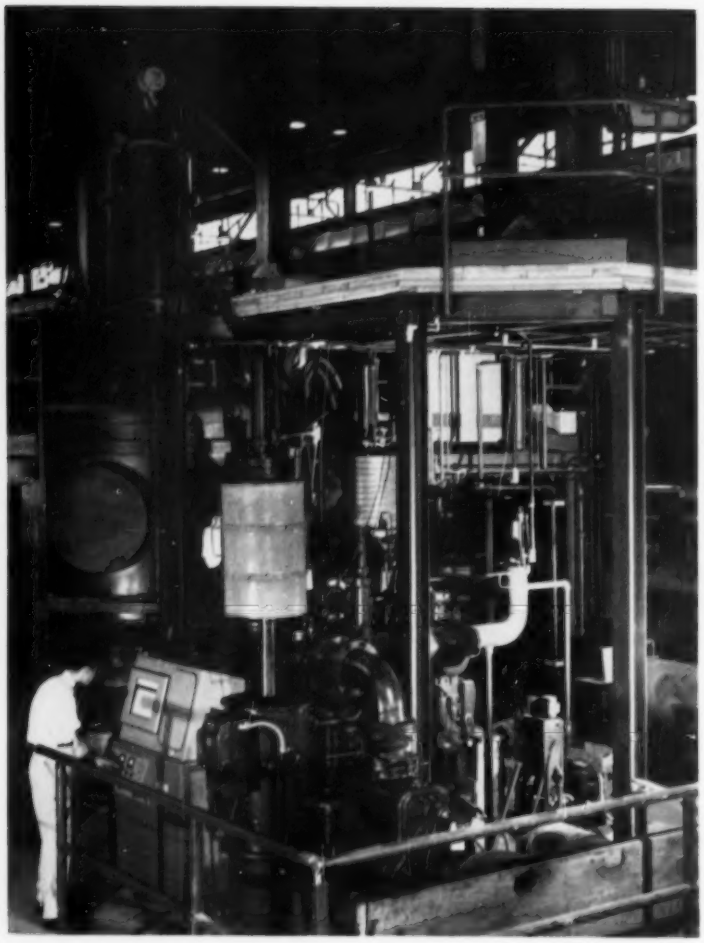
The 50 to 200-lb. unit is unique. The melting crucible is placed in a Micarta tube which is internally cooled by water-cooled copper coils. Around the Micarta tube is an external induction coil, which, because of its position, poses no insulation problems at high coil voltages. The furnace can be used for lip or bottom pouring. The small size of the vacuum tank for the size of the heat makes it ideal as a laboratory and semiproduction tool. It has the same accessories as the 1000-lb. furnace.

Advantages of Cold-Mold Melting

Present designs of jet engines demand stronger alloys made of chromium, molybdenum and higher melting point metals without the chemical segregation sometimes found in present high-temperature alloys. Cold-mold melting not only consolidates chromium and molybdenum by melting them without contamination from any crucible material, but also produces rapid and directional solidification, both of which minimize segregation.

For nuclear power generating equipment, it offers the best method of producing high-purity ingots of zirconium, uranium, plutonium and thorium. The corrosion resistance of zirconium alloys has been shown to be extremely sensitive to small amounts of impurities and today arc cold-hearth melting is the only available method capable of producing the desired purity.

A 12-in. diameter cold-mold furnace has been installed for these purposes. It can operate with either a consumable or nonconsumable electrode



Induction Vacuum Melting Furnace Used for 300 to 1000-Lb. Heats

in an inert atmosphere or vacuum. The ingot is continuously withdrawn and the withdrawal rate is automatically controlled so the position of the top of the bath remains fixed. Thus a given distance can be maintained between the electrode and the bath. The 40-v., 16,000-amp. d.c. power supply provides sufficient power to produce an ingot at the rate of 1 in. per min.

Auxiliary Equipment

A 16-in. consumable-electrode furnace for remelting ingots made in the 12-in. furnace is also available. It can be operated either at a partial pressure or in a vacuum. Smaller furnaces for product and process development are available. Three are capable of nonconsumable or consumable-electrode melting. They can produce ingots from 2½ to 4 in. in diameter and 24 in. in length. A fourth consumable-electrode furnace is capable of producing ingots 4 to 6 in. in diamemter and 30 in. long. A nonconsumable electrode has been built into the furnace for hot topping the ingots and the furnace can operate in an inert atmosphere or in vacuum.

Because of the wide variety of alloys and the range of the melting equipment, it was necessary to install a direct-reading spectrometer and X-ray fluorescence instrument as well as wet chemical analysis equipment. Usually it is possible to obtain an analysis prior to pouring the heat, so that necessary adjustments can be made.

By having an adaptable, yet complete metallurgical facility, Westinghouse believes it can carry research developments through a pilot-plant operation to production in a minimum of time. Such a facility, long a dream to metallurgists, should be a great aid in solving alloy problems of the future.

The Fusion Reaction*

WE NOW believe that the heat of the sun and of other stars comes from thermo-nuclear reactions continually going on in the center of such stars under the high temperature and pressure that exist there. It therefore seems appropriate to begin with a quotation from a distinguished astrophysicist, Lyman Spitzer, Jr.:

"By far the greatest reserve of stored energy on earth is locked up in the nuclei of hydrogen atoms present in the waters of the oceans. Deep inside the sun and the stars, such hydrogen nuclei combine to form helium nuclei, releasing vast energies. This combination of light nuclei is called 'thermo-nuclear burning' or fusion, and occurs most readily with deuterium, a heavy isotope of hydrogen. Although only one deuterium nucleus is present in ocean water on the earth for every 6400 nuclei of ordinary hydrogen, the total is enormous — conservatively estimated as sufficient to provide the present rate of world energy consumption for many billion years."

Evidently, the rewards of success are great. Unfortunately, the probability of immediate success is not. Again quoting Professor Spitzer:

"Thermo-nuclear burning occurs only at enormous temperatures, above a hundred million degrees, hitherto existing only at the centers of very hot stars or during the explosion of an atomic bomb. To convert the energy in the earth's deuterium into useful power, we must achieve such temperatures in a gas, confined within walls that remain relatively cool, control the reaction as it occurs, and extract the energy released and use it to generate electricity."

Fusion reactions between very light atoms were known in principle considerably earlier than fission of the very heavy ones. Both depend upon the fact that atomic nuclei are built of protons or positively charged particles and neutrons or uncharged particles (with the single exception of hydrogen, the lightest atom, H^1, whose nucleus is a single proton). Deuterium, which is another form or isotope of hydrogen, has in it one proton and one neutron. The next lightest, a more rare and unstable form of hydrogen called tritium, has in it one proton and two neutrons. The next, helium, has two protons and two neutrons — and so it goes.

Protons and neutrons are not equally tightly packed in the various atomic nuclei. The more tightly packed the more difficult it is to tear the nucleus apart and, conversely, the more energy would be released if the atom were to be built up of its constituents. If we could start with two deuterium nuclei, each containing one proton and one neutron, and "fuse" them into one helium nucleus (which is much more tightly packed) we could obtain a surplus of energy.

Unfortunately, there are very strong electrical repulsions between the positively charged nuclei. Hence two nuclei have to approach each other at enormous speeds before they can get close enough to react. The necessary speeds can be produced in the laboratory by ionizing atoms and accelerating them in an electrical machine such as the cyclotron or the cosmotron. However, these require much more energy to speed up the nuclei than is released in the reaction itself.

Another way is to raise the temperature and pressure. This, apparently, is the way the stars do it. The difficulty on earth is that the required temperatures are millions of degrees. Such temperatures have been achieved on the earth, so far as we know, only in atomic bombs. But for a fusion reaction to be useful other than as an explosive it must be under such control that we can get useful energy from it.

Here we run into problems of materials. Long before a million degrees is reached, every substance turns into a gas. But do we have to have a container to confine the reacting substance? There is no material envelope which holds the sun together. The hot gases are held in place by the force of gravity — evidently impossible for a power plant.

But there are electric and magnetic forces which, like gravitation, act at a distance on material bodies. We should also remember that outer electrons of atoms are knocked off as collisions occur at higher and higher temperatures (that is to say, speeds) and this occurs at temperatures much lower than those needed to produce nuclear reactions. Consequently, when we talk about "gas" at a million degrees, we are talking about an assemblage of charged particles differing substantially in properties from the neutral molecules of the gas at ordinary temperatures.

Astrophysicists are familiar with this kind of gas at the high temperatures in stars. Earthbound physicists are familiar with it at moderate temperatures in electrical discharge tubes. They know that such a "plasma" responds to electric and magnetic fields and that electric energy can be fed into such gas, thereby raising its temperature.

It may therefore be possible to heat deuterium, electromagnetically, to where thermo-nuclear reactions set in, and at the same time to confine this reacting gas by some arrangement of electric and magnetic fields.

If this is feasible, there still remains the problem of recovering the energy generated.

If the energy can be recovered, there is still the question as to whether an operating device will consume more energy than it generates.

If all this is achieved, there still remains the question of cost. The scientfic and technical difficulties are obviously formidable.

*Excerpts from a talk by Henry DeWolf Smyth before the National Industrial Conference Board's conference on atomic energy in industry. Dr. Smyth is Chairman of Engineering and Scientific Research at Princeton University, is a former member of the U.S. Atomic Energy Commission, and is the author of the so-called Smyth Report — "A General Account of the Development of Methods of Using Atomic Energy Under the Auspices of the U.S. Government, 1940 to 1945".

New Russian Metallurgical Publications

*By A. G. GUY**

Two new Russian magazines, which recently became available, indicate that activity in metallurgical research and development has increased in the U.S.S.R. and its quality and quantity are approaching those of the free nations. (A general, U 8)

THE FLOW of technical information on metallurgical subjects is predominantly from the western countries to the Soviet orbit with only a trickle in the reverse direction. One might smugly conclude that the flow is naturally downhill but there are many indications that such a complacent attitude is unrealistic. The first Russian nuclear explosion jarred the opinions of many who had grossly underestimated Russian engineering capabilities. In a much less spectacular manner, the recently available metallurgical publications have awakened us to the fact that any technical superiority the free world may have over Russia is slight.

Three factors largely account for the greater success of Russian metallurgists in assimilating "foreign" literature. First, the languages that Russians learn in school are English, French and German, while in this country Russian continues to be a minor language in most universities. Second, there is a vigorous program of technical translation and publication in Russia by the "Publishing House for Foreign Literature". The excellent A.S.M. book, "Alloying Elements in Steel" by E. C. Bain, was issued in such a translated edition. The third factor is the availability in Russia of foreign technical literature while many important Russian metallurgical journals have not been available to outsiders.

The problems of teaching Russian in American schools and of increasing the volume of technical translations are domestic ones that merit more attention than they are receiving at present. The third factor is under Russian control and it is this one that has recently assumed a definitely favorable aspect.

During the past several months a number of important Russian metallurgical journals have become generally available. Some of these, such as *Staľ* (Steel), had not been exported in years. Others are new journals, which may be replacing defunct predecessors but which undoubtedly also satisfy a need for additional publication mediums.

Metallography and Heat Treatment

"A monthly, scientific-technological and production journal," announces the masthead of the first issue of *Metallovedenie i Obrabotka Metallov* (Metallography and Treatment of Metals) published by the Ministry of Heavy Machine Construction and by the Central Science Research Institute of Technology and Machine Construction. The masthead also carries the slogan,

*Professor of Metallurgical Engineering, Purdue University Lafayette, Ind.

"Proletariat of all countries, unite!". However, it is only moderately conspicuous, in keeping with the nonpolitical nature of the technical articles. Even the opening paragraph of the editor's preface reflects the excitement of industrial progress more than a belligerent competition. "The Communist Party of the Soviet Union mobilizes and inspires the workers for the solution of the majestic task of creating communism in our land. A steady growth of the productive power of our country is essential for a strong and universal development of the material, industrial basis of communism. The most important, decisive requirement for our progress toward communism is the rapid growth of heavy industry and its core – machine construction, which outfits all branches of our native economy with advanced mechanical techniques".

The new journal is for the scientists, engineers and production men in the metallurgical industries. Their combined efforts are needed for the development of new alloys, the creation of superior methods, the conservation of scarce or expensive metals and the improvement of production machinery. The journal is to be an effective medium for the pooling of information on the broad theme – the relationships among the composition, structure, treatment and properties of metals.

The introductory section concludes with an exhortation titled, "Broaden the application to production of the results of metallography and heat treatment!" The pioneer efforts of D. K. Chernov and P. P. Anosov are discussed as well as the later work of groups of metallurgical scientists in Moscow, Leningrad, Sverdlovsk, Kiev and Dnepropetrovsk. Specific problems requiring attention are: high-temperature and other special-purpose alloys; alloys and cermets for atomic energy applications; improvement of present alloys for machine construction; widening of knowledge about multicomponent systems and about subgrain structure; improvement of high-strength cast iron; increased theoretical understanding of phase transformations; more effective utilization of salt-bath techniques; improvement of surface hardening processes; further development of controlled atmospheres and heat treating furnaces; improved understanding of distortion during heat treatment; better testing and laboratory techniques and more automation of technological processes.

In the first issue there are ten technical articles which cover a broad range of subjects from warping of automotive gears and toolsteel tempering problems to a highly technical review of the effect of crystalline structure on strength. For example, in "Stabilization of Residual Austenite in High Speed and High-Chromium Steels by Tempering" Y. A. Geller and R. P. Leshchinskaya report an investigation to learn why tools made of these steels were erratic with regard to the number of temperings that were needed to eliminate all of the residual austenite. They studied the effect of holding the quenched steels at room temperature for various lengths of time before the tempering operation and found that the amount of retained austenite present after a single tempering at 1040° F. increased from 7% for a holding time of 1 hr. to 11% for 24 hr. A second tempering eliminated the 7% retained austenite but a third tempering was needed for the 11% specimen. If the quenched steels were held at 480° F. rather than at room temperature, only 1 hr. was required to stabilize the austenite so that three temperings were necessary. It was concluded that the cause of the erratic tempering response in production heat treatments is the variable holding times.

Automotive Problems

Warping in transmission gears at the Gorky Automobile Factory was believed to be aggravated by the presence of some coarse-grained steels among the supposedly fine-grained steels being used. Work on this problem is reported by N. M. Tarasov and M. R. Semenchenko in the paper, "Influence of Grain Size of Steel 20KhNM on the Distortion and Strength of Automobile Gears During Heat Treatment". This steel is a carburizing grade containing 0.2% carbon, 0.6% chromium, 1.7% nickel and 0.2% molybdenium. Test gear-forgings were made from two heats of steel, one with a coarse grain size, 3 to 5, and the second with the normal fine grain size, 6 to 7. After the gears had been given the usual carburizing heat treatment, 36% of the coarse-grained steels were warped more than the permitted tolerance while less than 4% of the fine-grained steels were out of tolerance. The bend strength of the teeth from the fine-grained steel was about 25% higher than teeth from the coarse-grained steel. The authors concluded that closer inspection of this steel for grain size should be made.

"Structural Transformations in Metal Chips Removed by High-Speed Machining" was reported by E. I. Fel'dshtein of the Molotov Laboratory for Machining of Metals, a section of the Gorky Automobile Factory. Although there have been many reports of microstructural changes

produced in chips by the heat generated in machining, no evidence was found of any phase change or of any change in shape of the cementite particles in the spheroidized or pearlitic steels used. The test conditions included both sharp and dull carbide tools, speeds up to 4000 ft. per min., 0.12-in. depth of cut, and feeds up to 0.012 in. per revolution.

N. A. Fertik reports some interesting results on "The Effect of Preliminary Heat Treatment on the Brittle Strength of the Nitrided Layer of Steel 38KhMYuA". This steel is a nitriding grade and contains 0.4% carbon, 1.5% chromium, 0.9% aluminum and 0.2% molybdenum. He found that the Ac_3 temperature of this steel is 1560° F. rather than 1720° F., the value given in the literature. Therefore, he lowered the hardening temperature to 1650° F. and found that it gave the highest bend strength and a case depth as great as that produced by higher hardening temperatures. He also found that the bend strength increased continuously with increasing rate of quenching. Finally, he tried induction hardening in which the specimen was heated at 1950° F. for about 1 sec. and found that this hardening treatment improved the bend strength and produced a finer grain structure.

"Current Ideas on the Structure of Alloys in Connection With the Strength Problem" by I. L. Mirkin is based on 31 papers, 11 of which are from foreign journals including five from *Acta Metallurgica*. Topics considered included: the nature of grain boundaries, their chemical composition, viscosity and strengthening effect; mosaic structure; coherency in precipitation hardened alloys; and properties of zone-refined aluminum. Special attention was given to the static displacement of a lattice caused by foreign atoms and to the dynamic displacements that constitute thermal vibrations of the lattice. The dynamic displacements are rather small, about 0.01 Angstrom in an alloy of cobalt in iron, but the static displacements are surprisingly large, 0.23 A at 20% cobalt. The difference in atomic radii of iron and cobalt accounts for only about one-fifth of this displacement. The hardness and strength of solid solutions are found to correlate well with the degree of static displacement.

Papers on Electrical Sheet

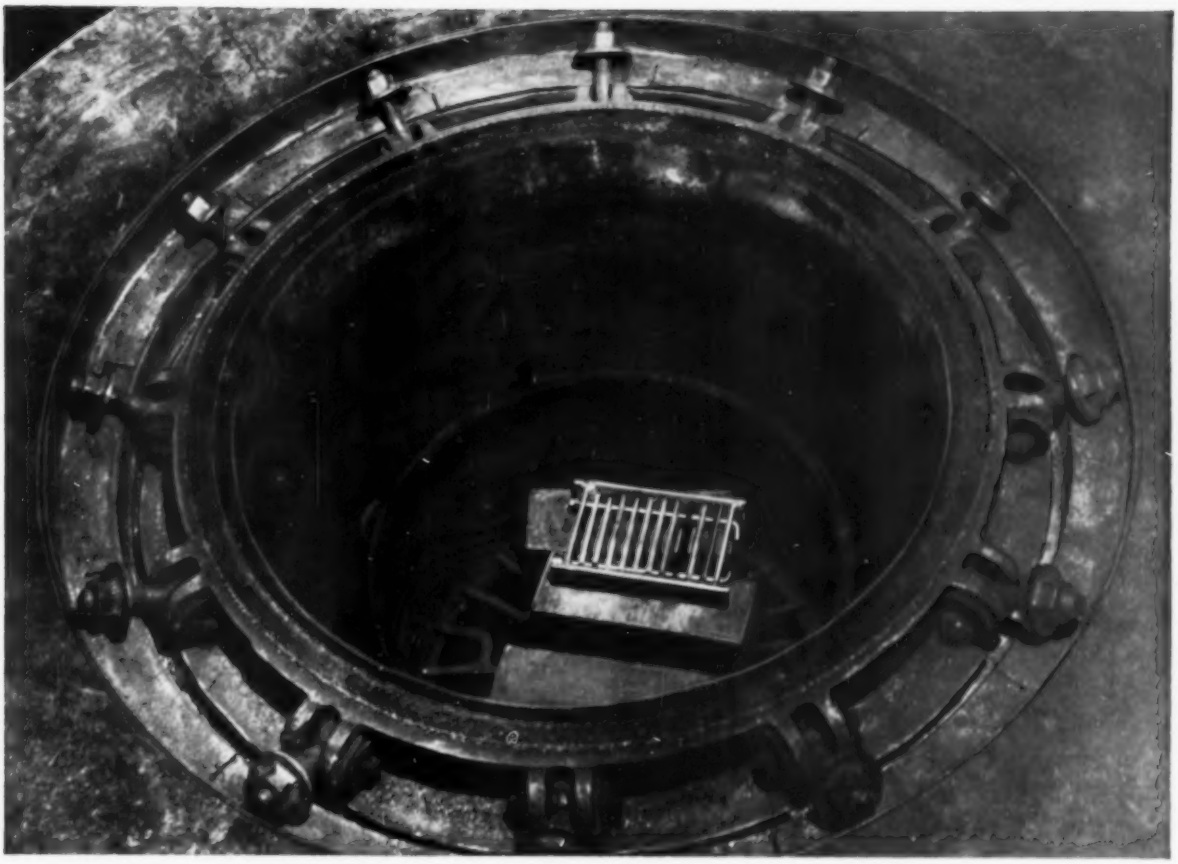
The first issue of *Physics of Metals and Metallography (Fizika Metallov i Metallovedenie)* is devoted entirely to the reports of a conference on the problems of production, application and quality control of electrical sheet steel. There are 26 papers covering topics ranging from the magnetic domain structure of single crystals of silicon ferrite to problems met in the rolling of commercial transformer steel.

I. N. Bogachev and co-workers reported on "The Influence of the Form of Carbon on the Magnetic Properties of Transformer Steels". They found that the form in which the carbon was present had more effect on the coercive force of hot rolled 4% silicon steel than did moderate changes in total carbon content. For example, when thoroughly annealed steel was given a second pack anneal at 1560° F., the coercive force was 50% poorer although the carbon content had decreased from 0.018 to 0.013%. Study of the microstructure showed that the cause was a redistribution of part of the cementite from the grain boundaries to the centers of the grains. The magnetic property could be restored to about the original value by a treatment, such as annealing in a vacuum, that causes the cementite to change to graphite. Precipitation of cementite from supersaturated ferrite had an especially harmful effect on the coercive force. Thus, this research explained the sources of erratic property variations during commercial heat treatment of transformer sheet.

V. S. Meskin and N. I. Lapkin reported on another study of heat treatment, "The Effect of High-Temperature Annealing and Repeated Heating on the Magnetic Properties of Electrical Steels". Their work showed that industrially important magnetic properties of transformer steels could be improved by annealing at temperatures up to 2550° F. instead of the usual 2000 to 2100° F. Also, a "refining" atmosphere of hydrogen or a vacuum gave better results than did an inert atmosphere such as argon. Vacuum was somewhat superior to a hydrogen atmosphere since absorption of hydrogen by the steel was avoided.

Conclusions

These two new journals give western metallurgists a greatly increased opportunity to follow metallurgical developments in Russia. The observed expansion in publication presumably reflects an increase in metallurgical research activities. While it appears that the western countries are still ahead in quantity and average quality of metallurgical research and development, their advantage is only a limited one. How long it is maintained will depend in part on how effectively western metallurgists make use of the available Russian technical literature.



Investigation of metal behavior in actual industrial environments is facilitated by the installation of a heat-resistant, alloy test rack containing numerous metals and alloys. Here is such a test rack, installed for a dozen carburizing cycles in a pit-type, circular Hevi-Duty furnace at Benedict-Miller, Inc., Lyndhurst, N. J.

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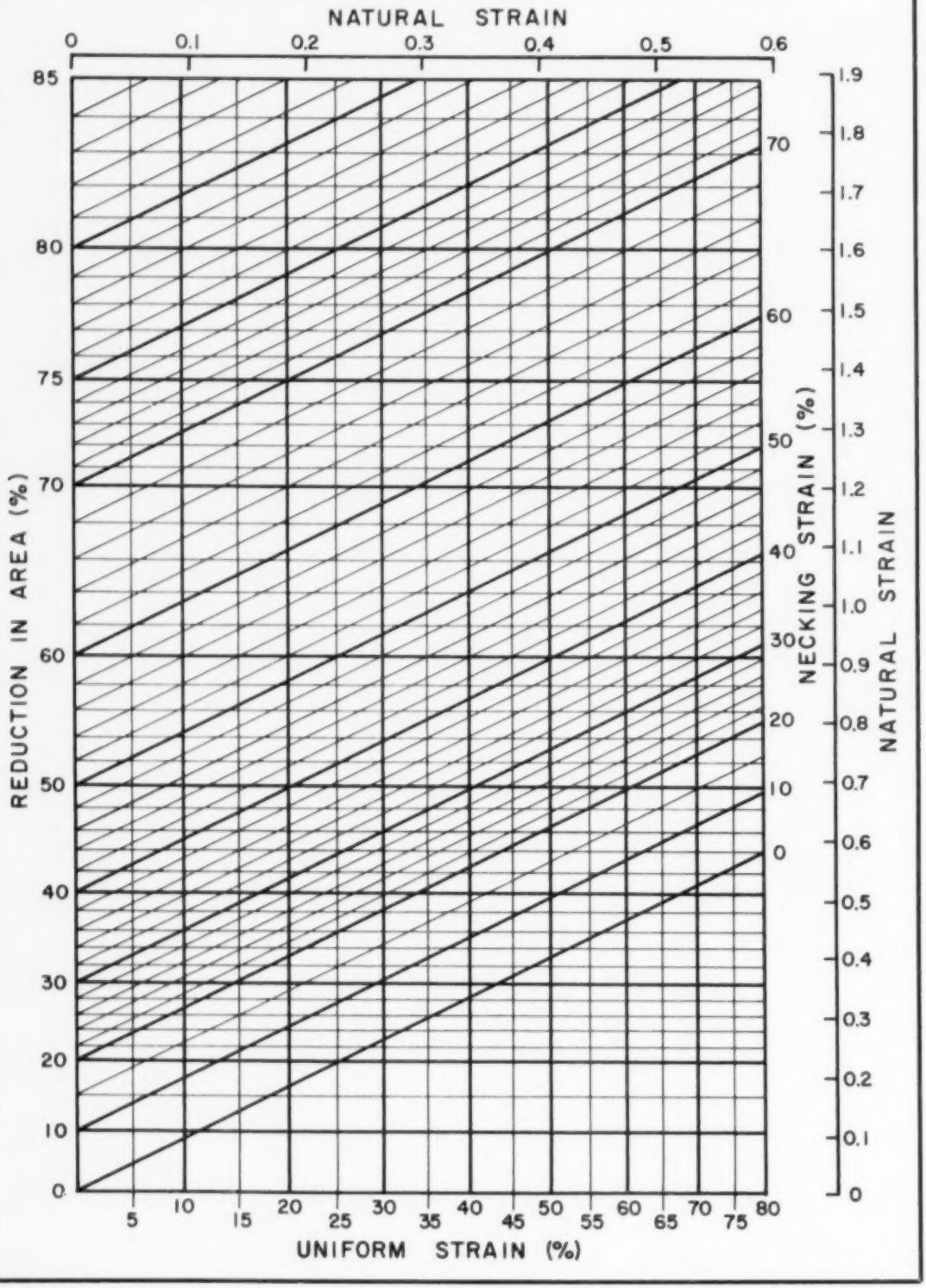
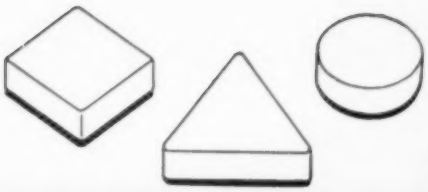
A Nomograph for Strain Conversion

By F. Forscher, Atomic Power Div., Westinghouse Electric Corp., Pittsburgh

The chart may be used to convert different ductility measurements without calculation. Explanation and examples are given on page 96.





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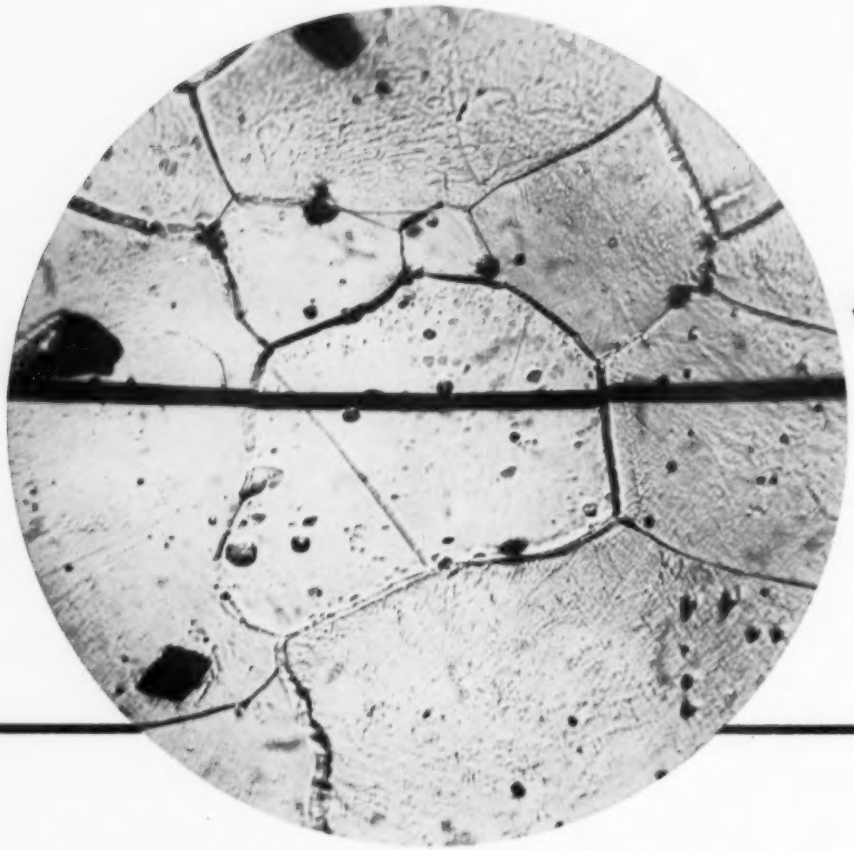
BLUE RIBBON AWARD WINNER for best photomicrograph in the *Results by Unconventional Techniques* Class—Mr. Robert O. Quinn, American Can Co., Barrington, Ill. (Deceased, Jan. 23, 1955).



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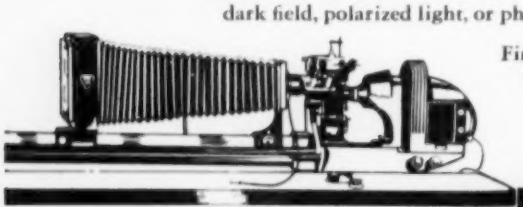

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Choice of High-Temperature Alloys

Influence of Fabrication History

*By NICHOLAS J. GRANT**

Most important is the crystalline condition and its stability. An alloy whose crystals can absorb the maximum amount of deformation (with resulting strengthening) and retain this without recrystallization to the highest temperature will probably have the highest rupture strengths. (Q general, N 5, SG-h)

MORE or less by trial and error, we have arrived at several alloy types which have reasonably good mechanical properties at all temperatures up to full red heat. Designers of gas turbines, especially, are anxious to boost this maximum temperature greatly. It will be the aim of the present article, and its sequel, to inquire whether such alloys can be "designed" or formulated with the metals now commonly available and, if so, what principles will direct the way toward success. To keep the discussion within the realm of acquired facts rather than of fancy, let us set a temperature of "more than 1250° F."

It would not seem to be too difficult to assess those features which lead to successful alloys for use above 1250° F. in view of the fact that such alloys now exist. It might appear therefore that we are shadow-boxing – except insofar as refinements in composition and application are concerned. However, much may be learned from a careful consideration of existing alloys, whether they are wholly or only partially successful, if some working hypotheses can be extracted which might lead to improved alloys or to wholly new alloys of superior properties.

Consequently we will start by examining current alloys to see if there are common features in their formulation or structure, or if advantage has been taken of such factors or known alloying

*Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass.

Table I – Properties of Cast Versus Forged Alloys*

Alloy	Temperature	Stress	Forged Pieces		Castings	
			Rupture Time	Elongation	Rupture Time	Elongation
N-155	1500° F.	20,000 psi.	115.0 hr.	18.0%	155.0 hr.	8.0%
S-497†	1500	20,000	43.5	24.0	174.5	8.9
MT-9	1500	20,000	27.0	11.7	204.6	4.6
S-816	1500	28,000	92.5	10.0	120.0	3.0
S-816	1600	18,000	30.0	15.0	100.0	17.0
S-816	1800	10,000	6.0	19.0	110.0	10.0

*N. J. Grant; "The Stress-Rupture and Creep Properties of Heat Resistant Gas Turbine Alloys", *Transactions* of American Society for Metals, Vol. 39, 1947, p. 281.

†15% Cr, 20% Ni, 20% Co, 4% Mo, 4% W, 4% Cb, 0.4% C, bal Fe.

principles. This first article will be concerned largely with alloys which are substantially single-phase in microstructure, leaving a review of multiphased alloys and mixtures of metals and nonmetallics to a subsequent issue.

Melting Points and Recrystallization

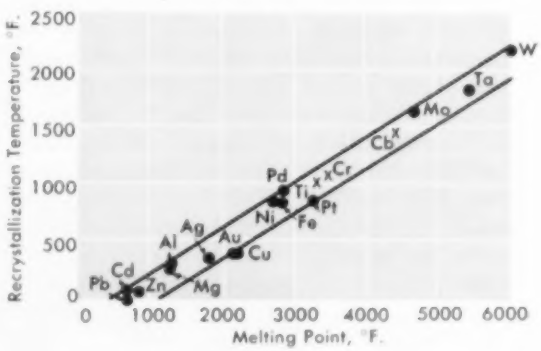
No doubt the melting point of the element or elements on which the alloy is based must be high. On the other hand, up to about 5% of certain elements of much lower melting point can be added without detracting from the refractory nature or the properties of the alloy. Once one converts a metal into an alloy, then the melting point becomes of somewhat less importance than the recrystallization temperature in determining high-temperature performance. The relationship between these two properties is shown in Fig. 1 for several important metals.

The minimum recrystallization temperature is approximate. The latter values are for the pure metals in most instances, but the relative purities are not the same, nor are they always accurately known. Nevertheless, Fig. 1 offers some interesting generalizations concerning metals for high temperatures. For example, we know that pure aluminum is stronger than pure zinc; similarly, pure copper is stronger than pure aluminum at elevated temperatures. On moving downward from the top of the curve, we find that tungsten is stronger than molybdenum; molybdenum is stronger than iron, nickel or cobalt; and iron, nickel and cobalt are each stronger than copper at high temperatures.

Correspondingly, in alloys based on these individual metals a similar arrangement holds – namely, the best-known aluminum alloys are stronger than the best-known zinc alloys. The best copper alloys are stronger than the best aluminum alloys; the best nickel-base alloys are stronger than the best copper-base alloys. Going on up the band in Fig. 1 to where there is a large jump from iron, nickel and cobalt to molybdenum, we know that even large additions of alloying elements to the former are inadequate to raise their recrystallization temperatures to that of pure molybdenum. At 1800° F. pure molybdenum is stronger than the best alloys of any of the other alloy systems, and simple alloys of molybdenum are even stronger than the pure molybdenum.

Based on these observations, a number of less familiar metals appear to offer promise for high-temperature strength. These include titanium, vanadium, chromium, columbium, tantalum, and tungsten. There is a possibility that the elastic modulus may modify this deduction from the observed trend. For example, consider the supposedly poor creep properties of titanium and its alloys above 1000° F. This conclusion remains to be proven, since relatively complex alloys of titanium have not been investigated to any important degree. Other considerations such as specific gravity, cost, availability, oxidation resist-

Fig. 1 – Approximate Relation of Recrystallization Temperature to Melting Point of Pure Metals. Note positions of titanium, chromium, and columbium

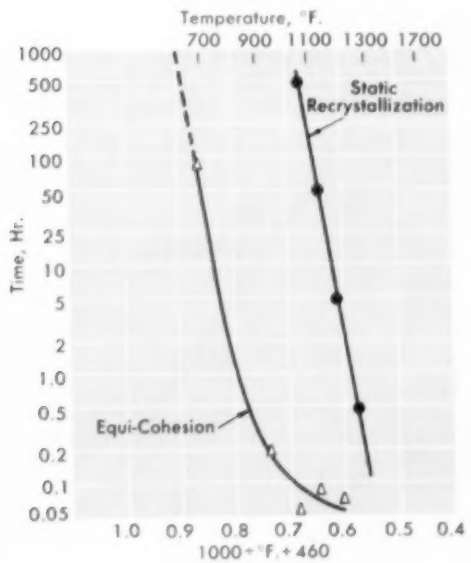


ance, or reactivity with a particular atmosphere, may present practical limitations to the utility of these metals of high melting point – ranging from titanium to tungsten – for high-temperature alloy systems.

In the meantime, research on high-chromium alloys has already brought forth a number of interesting possibilities. High strength at 1600 to 1800° F. has been shown by chromium-base alloys such as the experimental CM-469 alloy (60% Cr, 25% Mo, 15% Fe) studied at Battelle Memorial Institute – which unfortunately suffers from sigma-phase embrittlement – and by another whose composition is 70% Cr, 21% Fe, 9% Mo. Alloys based on the chromium-nickel binary system have also shown interesting properties at 1800° F., the stress for rupture in 100 hr. at 1800° F. being about 9000 psi., a value greater than that for forged S-816* or any of the forged nickel-base alloys, age hardened with the aid of titanium plus aluminum.

It would be nice if we could estimate or measure a recrystallization temperature for an alloy as a guide to its high-temperature usefulness. This is especially true for service higher than 1250° F., because it has become increasingly difficult to find, experimentally, recrystallization temperatures above 1250° F. Our knowledge of the phenomenon is based almost exclusively on *static* recrystallization, wherein deformation at room temperature is followed by a heat treatment. Is this static recrystallization temperature the best measure of the incidence of high-temperature processes?

Fig. 2 – Time-Temperature Relationships for Equi-Cohesion, Based on Creep-Rupture Tests of 30% Cold Worked Monel, Versus Static Recrystallization After 30% Cold Work



During the past three or four years the present author has made a number of comparisons between this static recrystallization temperature and the lowest temperature at which a cold worked metal shows evidence of recrystallization during a creep-rupture test. This can be regarded as a type of dynamic recrystallization. For example in Monel metal – a nickel-copper solid solution – dynamic recrystallization appeared at least 200° F. lower than could be predicted from extensive static recrystallization studies. This is shown in Fig. 2. Static recrystallization is after 30% cold work and for annealing times up to 500 hr. The curve marked "equi-cohesion" plots the first evidence of new grain formation in creep-rupture specimens which also had been cold worked 30% prior to testing. These data have been substantiated in similar studies of cold worked Type 347 stainless steel; again a differential of about 200° F. exists.

Recrystallization must be considered in the broadest sense. The formation of new grains may not always be evident in deformed creep specimens; instead, recrystallization may manifest itself more subtly via grain-boundary migration, grain growth, or possibly even by generally undetectable recrystallization in thin layers along grain boundaries. The overlap of recovery processes and recrystallization presents a further complication. Thus, the whole subject deserves much additional thought and experimental effort to fit it into the theory and pattern of creep and fracture. Measurements of recrystallization under superimposed strain at temperature would help determine the minimum temperatures at which grain-boundary processes (and therefore the high-temperature type of deformation and fracture) will become operative.

Castings Versus Forgings

The limited data available indicate that, for a given composition followed by comparable heat treatment, castings possess higher hot strength and creep resistance than do forgings. Table I compares a number of Ni-Cr-Co-Fe alloys which

*S-816 has typically 42% Co, 20% Ni, 20% Cr, 4% each of W, Cb, and Mo, 3% Fe, and 0.5% C. Strengths of jet engine alloys are summarized in *Metal Progress* data sheets in September 1955, and January and February 1956.

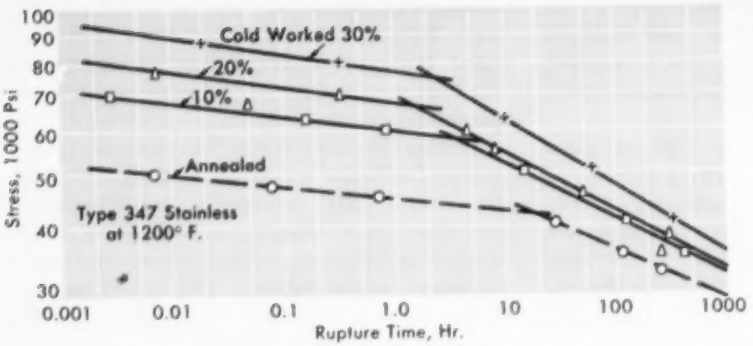


Fig. 3 – Log-Log Plot of Stress Versus Time to Rupture at 1200° F. for Type 347 Stainless Steel After Various Amounts of Cold Work

bear this out. It appears that the dendritic solidification network tends to strengthen the alloy – barring unusual segregation at grain boundaries. This is an important consideration in the selection of alloys for particular applications where either wrought parts or castings can be used, especially when one considers the greater range of compositions available when forgeability is not a limiting factor. Again, recrystallization plays an important but poorly defined role. Grain size, shape and orientation pose other as-yet unanswered questions.

Forged alloys are almost always more ductile than castings; structural control and specification of properties are also usually simpler. Castings are generally subject to greater variation of grain size, especially in the neighborhood of large changes in section. Control of structure in castings has been demonstrated, however, and defective structures need not be tolerated.

Whereas fatigue properties are usually superior in wrought products, this is not always true for thermal shock resistance.

Grain Size Effects

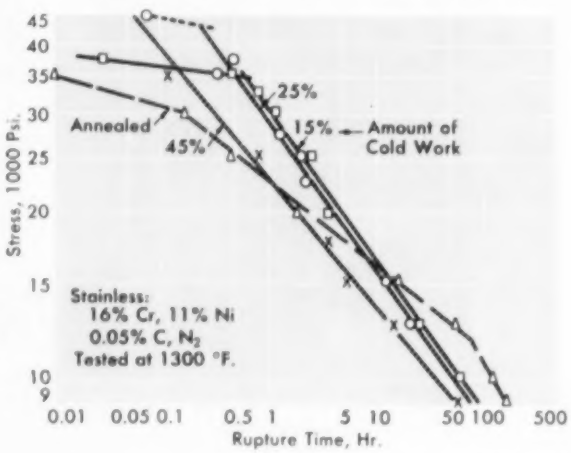
The effect of grain size on the performance of an alloy at high temperature is a complex subject which can hardly be covered by a simple generalization. The bulk of the experimental evidence indicates that coarser-grained structures show superior creep-rupture properties at high temperatures over the fine-grained structures. In fatigue tests the opposite conclusion can be drawn. Unfortunately, production of a coarse grain size in our complex commercial alloys, should one be desired, is frequently complicated by other structural or chemical changes which mask or even reverse the expected result on properties. Thus, if a coarse grain size is produced, one may also find a coarser carbide spacing or changes in response to aging heat treatments.

An equally important consideration is the evidence existing that beyond a certain point too coarse a structure results in large variations of properties due to orientation effects and consequently properties and performance are irreproducible. In any event, the selection of a grain size depends largely on the nature of the application – type of stresses, atmosphere, size of part and so on.

Cold and Warm Work

In the course of creep-rupture testing at progressively higher temperatures, one always notes a disproportionately large drop in strength and creep resistance when recrystallization occurs. Recrystallization is clearly associated with the phenomenon of equi-cohesion, or the initiation of intercrystalline fracture under stress at high

Fig. 4 – Log-Log Plot of Stress Versus Time to Rupture at 1300° F. for Low-Carbon Plus Nitrogen 16-11 Cr-Ni Stainless After Various Amounts of Cold Work



temperature. It is also closely associated with "recovery" at slow strain rates.* However, up to the time and temperature where the metal starts to recrystallize (or recover at lower strain rate tests) the energy stored in the metal lattice during the plastic deformation of cold or warm working permits it to withstand higher stress.

For example, Fig. 3 shows the benefits to be derived from cold work on Type 347 stainless steel when tested at 1200° F. For all degrees of cold work up to 30%, the rupture life (and creep resistance) is higher than for the usual annealed condition. For stresses at 1100° F., these increases were more spectacular and would be effective beyond 30% cold work. The benefits of cold work are retained at lower temperatures, and for longer periods of time at higher temperatures, the less the amount of cold work. It is fortunate that working is so important; otherwise a very large amount of alloying elements would be necessary to achieve the same improvements.

*Recovery, in the simplest terms, is stress relief or relief of residual stresses due to prior deformation – local or general.

Fig. 5 – Effect of Annealing on the Width of the (220) Line in an X-Ray Diffraction Pattern From Solution Treated, Low-Carbon N-155, Cold Worked 13% at 80° F. (From "Fundamental Effects of Cold Working on the Creep Resistance of an Austenitic Alloy", by D. N. Frey and J. W. Freeman, Transactions of the American Institute of Mining, Metallurgical and Petroleum Engineers, Vol. 191, 1951, p. 755)

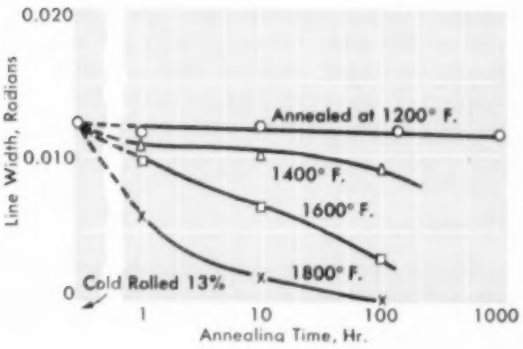
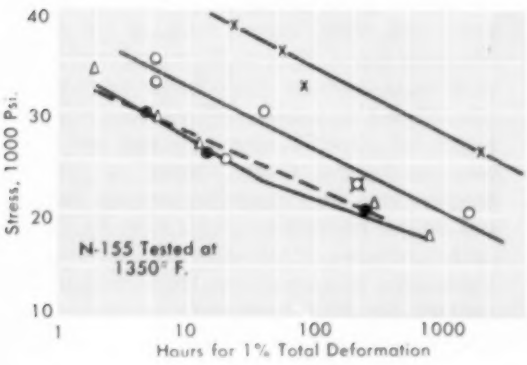


Fig. 6 – Stress and Time Required for 1% Deformation of Low-Carbon N-155, as Rolled, After 15% "Warm Work", and After Two Heat Treatments. (From "Properties of Low-Carbon N-155 Alloy Bar Stock From 1200 to 1800° F.", by J. W. Freeman and A. E. White, National Advisory Committee for Aeronautics Bulletin RM 51B05, May 3, 1951)



When recrystallization does take place, one frequently finds that the cold worked structures now show lower strength properties than in the annealed condition. This is illustrated in Fig. 4; strength decreases at a more rapid rate in the more severely cold worked material compared to the annealed condition. It will be noted that for short rupture times, cold work still gives a markedly superior metal, the improvement increasing with the amount of cold work.

A number of important applications are based on the above principles. Strength and improved creep resistance due to "warm work" are one of the important aspects of the Timken 16-25-6 Cr-Ni-Mo alloy used for jet engine rotor disks. The same is even more important for higher alloyed materials with higher recrystallization temperatures. Consider N-155 alloy (variously called Multimelt or A.M.S. 5767 and A.M.S. 5768 – typically 21% Cr, 20% Ni, 20% Co, 3.2% Mo, 2% W, 1.1% Cb, 0.12% C, 0.12% N). This was developed for operation at rather high stresses in gas turbines and for certain jet applications in the 1300 to 1500° F. range. Figure 5, due to Frey and Freeman, shows the rate of annealing, as measured by change in width of the (220) line in an X-ray diffraction pattern, after heating in the temperature range of 1200 to 1800° F. after 13% cold work. It will be noted that even after 100 hr. at 1400° F. or 10 hr. at 1600° F. considerable strain or deformation of the lattice remains.

Translated into terms of the creep-rupture test, Fig. 6 shows that the benefits of 15% cold work are retained at 1350° F. for more than

Table II – Strength of Arc-Cast Molybdenum

Alloy	Condition	Stress for Rupture in 100 Hr.		
		1600° F.	1800° F.	2000° F.
Unalloyed	Stress-relieved	30,000 psi.	23,000 psi.	15,000 psi.
	Recrystallized	16,000	12,000	8,000
0.45% Ti	Stress-relieved	70,000	55,000	25,000
	Recrystallized	36,000	28,000	20,000
0.24% Cb	Stress-relieved	55,000	34,500	—
	Recrystallized	23,000	17,000	11,500

4000 hr., and that this cold worked structure is superior at this test temperature to that derived from the other heat treatments.

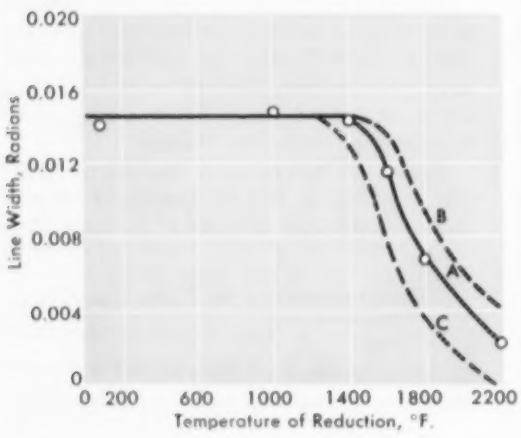
The higher the recrystallization temperature, the higher the temperature at which benefits in creep resistance or rupture life can be achieved. Figures for arc-cast molybdenum in Table II show the marked superiority of the as-worked and stress-relieved structure of pure molybdenum and of two of its alloys over the recrystallized structure. While there is a natural reluctance to deform high-strength materials as much as 15% in the cold, the benefits are large and have been utilized in many engineering applications.

Hot working is a process of equal importance but less well known and understood than cold or warm working. Such "hot" working of high-strength, heat resistant materials is, in fact, dependent on retained strains within the metal lattice. The amount of benefit (permanent deformation of the lattice) depends on the amount and rate of deformation, and the rate of cooling to some temperature where stress relief is no longer operative.

Figure 7 shows the increase in line width over the annealed state for alloy N-155 as a function of the temperature at which the alloy was deformed (15% in one pass). It will be noted that even on rolling a 0.875-in. bar, stresses are retained after cooling to room temperature. Theoretical positions for curves for larger and smaller bars are drawn in dotted lines. The larger bar of this material having a low coefficient of heat conduction cools more slowly and is stress-relieved more thoroughly. Hence the lower dotted curve. Similarly, a smaller bar, because it cools more rapidly, retains more of the strain induced due to hot working.

Freeman and his associates at University of Michigan have shown that correctly hot worked structures have superior creep resistance and rupture life when compared with the solution treated and aged condition. This is true for a number of important heat resistant alloys, but the full benefits and the structural changes or adjustments within the material are as yet not well understood.

Fig. 7 – Effect of Rolling Temperature on Width of (220) Line of Solution Treated, Low-Carbon N-155, Reduced 15% at Each Temperature. Curve A is for 0.875-in. bar stock; Curve B is the probable position of bars smaller in cross-section; Curve C is the probable position for heavier bar stock. (Freeman and White)



Conclusion

Several points emerge from the above cursory survey: In choosing the alloy and its heat treatment for best service at high temperature and where strength properties are of importance, one should remember that the temperature of recrystallization is of more importance than the melting point. Unfortunately such temperatures are not easy to determine accurately and much pertinent data are not yet available. In each alloy the recrystallization temperature will depend upon past history and especially upon the amount of plastic deformation during fabrication (cold work, "warm" work, or hot work). The latter aspect of the problem applies of course to wrought products. Nevertheless there is considerable evidence that an alloy casting will have higher hot strength, creep resistance and resistance to thermal shock; forging or working, however, may be expected to improve ductility and fatigue resistance.

The influence of alloying and of dispersed nonmetallic compounds on the formulation of material for high-temperature service will be discussed in a subsequent article.

Prestressing an Ultra High-Strength Steel to Perform Even Higher Duty

*By JEROME W. KAUFMAN**

A small ordnance forging made of high-strength steel which was failing in service was successfully replaced with another of identical design but made of an ultra high-strength steel heat treated to about 283,000 psi. tensile ultimate. (Q general, AY)

SOME time before the Korean conflict and as a result of many accidents in service wherein bomb hooks on racks and shackles suspended from aircraft had broken and the bombs dropped, a new lot of several thousand bomb hooks was ordered from a certain contractor. Commercial alloy steel of aircraft quality was to be used conforming to A.I.S.I. specification 4140 (1% Cr, 0.20% Mo), 4340 (1.75% Ni, 0.80% Cr, 0.25% Mo) or "Hy-Tuf" (Crucible Steel Co. of America's special product analyzing 0.25% C, 1.35% Mn, 1.50% Si, 2.0% Ni and 0.40% Mo).

Stringent mechanical tests of samples of production showed that the product was extremely variable. For that reason the Bureau of Aeronautics commissioned the Naval Air Development Center to determine the performance requirements for a suitable bomb hook, and recommend manufacturing details likely to meet these specifications. The hooks must be accommodated in the existing bomb racks and shackles, and at the same time be safe under increased bomb loads. The heavier "pay-loads" on the same racks and shackles meant that the hooks not only had to be stronger but also be able to take care of the constant increase in fatigue loading resulting from higher speeds in aircraft. As shown in Fig. 1, these hooks are rather small – about 2.62 in. overall in height – and weigh about ½ lb.

In fact we had a somewhat larger problem since it would be well to devise means of reclaiming or improving the parts already on hand. Bomb racks and shackles were already available in great numbers. It was necessary to increase the mechanical properties of the hooks and still retain their original dimensions. It turned out that both problems were related because the best heat treatments we could devise for the new order made of 4140 and 4340, when composition and processing were under thorough control,

*The author is now consulting metallurgist, Defense Electronic Products Div., Radio Corp. of America, Camden, N.J. When the work described in this article was done he was metallurgist for the U.S. Naval Air Development Center, Johnsville, Pa. Approval for publication has been given by the Naval Air Development Center, although the opinions stated are those of the author and not necessarily the official views of the Defense Department.

gave hooks that had the necessary static strength, but still were not satisfactory in fatigue resistance.

Mechanical Prestressing – Briefly, the corrective developed by the author was to stretch the hook in such a way that only the surface metal was deformed in the region where service fractures tended to start. During this time the great body of the metal is still in the elastic range. It will be immediately recognized that the effects of this operation are similar to the well-established surface peening which improves the fatigue resistance of springs and other highly stressed parts.

It may be well to recount the theory: After the load is relaxed the body of metal tends to return elastically to its original volume, but the surface layer has been given a permanent set and tends to remain elongated. The body of metal, being of enormously greater bulk, forces the surface layer to retract – that is to say, to be forced into compression; these surface fibers are then held in compression by the relaxed body of metal. Now when the hook is subjected to variable loads, as when it is carrying a bomb in a rapidly moving and intensely vibrating aircraft, the surface layer tends to be pulled apart in the same general direction as the direction of loading in the prestressing operation, and at a stress which varies rapidly over a considerable range. It is recognized that fatigue fractures start from tension cracks at the surface, and the prestressed hook will not start a fatigue crack until the surface fibers go out of compression and into a fairly high state of tension.

The same prestressing operation cold works the outer surface of metal by cold stretching, and this work hardens the surface and correspondingly strengthens it. In addition, prestressing of chromium-plated parts may largely eliminate the deteriorating effect in fatigue of the residual tensile stresses in the chromium plating itself.

Suffice it to say that the bomb hooks on hand – even those of acceptable static load-carrying ability – would fail after about 5000 alternations of a fatigue test, whereas after prestressing the same hooks would withstand over 25,000 cycles, an increase of about 500%. The equipment for prestressing and testing will now be described.

Prestressing and Fatigue Equipment

A perspective drawing of the assembly for prestressing the bomb shackle hook is reproduced in Fig. 1. It is in effect a universal mount in a tensile testing machine, so arranged for accurate alignment. The hook with two shim plates S is placed between the two cheek plates C and pins P and G slipped through corresponding holes. The main load is transmitted through a tightly fitting pin P; pin G goes through a vertically elongated hole in the cheek plates and, with the shims S, prevents side loads. The engaging surface between the lower fixture and the hook is horizontal. The lower fixture makes contact with the hook at its outer tip. This restricted location of contact, shown in the diagram, provides the maximum loading moment to prestress the greatest area of the critically stressed section of the hook.

Straining was at a slow rate, about 0.075 in. per min., until the specified prestressing load was reached (usually 19,000 lb.). This load was held for 30 sec., and released fairly quickly (no specified rate).

As above stated, this prestressing was applied to all shackle hooks in stock as well as those furnished on current contracts.

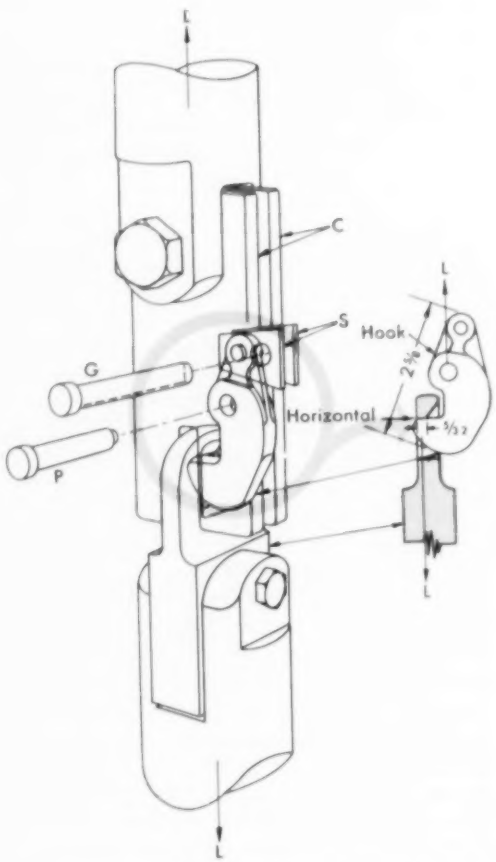


Fig. 1 – Assembly for Prestressing Bomb Shackle Hook in a Standard Tensile Testing Machine

The author designed a satisfactory fatigue fixture for simulating service loads on this hook and Fig. 2 is taken from the patent specification. It is mounted in a Sonntag SF 1 U machine capable of making a "pull-pull" test. The load range is +2000 to +8000 lb. – thus being an alternating load of ±3000 lb. superposed upon a pull of 5000 lb. Frequency is 1800 cycles per min.

In this fixture a pin 29 with flattened central portion to simulate the contacting surface of a bomb lug takes the place of the lower fixture in Fig. 1. This pin is loose enough in the lower fixture so it can rotate slightly as the load is applied and varied, so the upper and lower fixtures are automatically aligned to accommodate variations in the hook's configuration within the range of manufacturing tolerances. Pin 19 corresponds to pin P in Fig. 1, and is close fitting; it carries the full load. Pin 21 corresponds to G in Fig. 1; it fits through a vertically elongated hole in the upper fixture and thus provides only horizontal restraint.

The fixture as designed is stocky and rigid and thus provides for the uniformity in test setup – that is to say, exact duplication of point of load application – which long experience in simulated service fatigue testing has demonstrated to be essential for consistent test results.

Improved Hooks

This was the situation that existed, therefore, when demands were made for a stronger hook of the same size and weight. Prior to that time and even with close control of the manufacturer's routine, they could produce a hook which would carry a load of only 20,000 lb. in tensile test, and

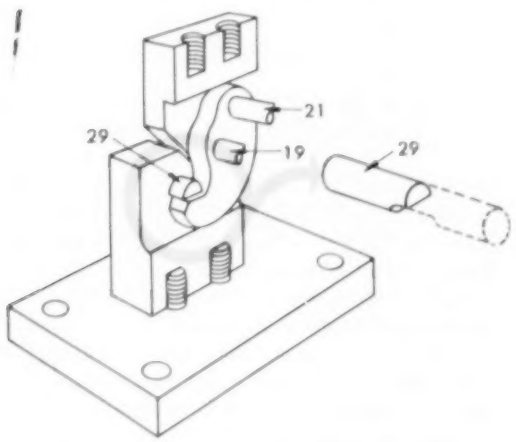


Fig. 2 – Sketch of Fixture (Split Vertically in Half) for Testing Hook in Fatigue

(after prestressing) endure 25,000 cycles in the fatigue test.

At the time, the high-strength engineering steels were regarded as having a maximum tensile strength of 230,000 psi. compatible with other mechanical properties at an optimum. This strength limitation was imposed by the undesirable phenomenon of blue brittleness in their heat treatment at the temperatures that would produce higher strengths. Theoretically very much higher strengths should be obtainable – possibly on the order of magnitude of Young's modulus of elasticity for steel, roughly 30,000,000 psi. Without discussing the reason for the large discrepancy between actual and theoretical (except to note that the current theory of dislocations aptly explains this discrepancy), it may be said that aircraft designers would welcome a modest boost in strength of, say, 50,000 psi. Several research programs had been under way, and three or four steel companies had put improved high-strength alloys on the market. This situation was discussed at the A.S.M.'s Western Metal Congress in March of 1953 and briefly reported in *Metal Progress* in the May issue of that year. In view of the fact that we, at the U.S. Naval Air Development Center, had a good background of experience and knowledge about the properties of the forged and heat treated bomb shackle hook made of the high-strength steels, it seemed logical that we should make a study of the same part when made of one of the new ultra high-strength steels.

The steel we selected was "Super Hy-Tuf Steel", made by Crucible Steel Co. of America, said to be heat treatable to a tensile strength within the 280,000 to 300,000-psi. range and to have good ductility for dynamic loading. The shipment which was processed into hooks for us had the following composition: C 0.42, Mn 1.27, Si 2.08, Cr 1.33, V 0.21, and Mo 0.34%.

Its ability to be heat treated to strengths approaching 300,000 psi. and still retain toughness is believed due to its content of silicon and vanadium. These elements enable this steel to be tempered in the "blue-brittle range" without any deterioration in properties. Also for the best accompanying properties it has a low carbon content compatible with necessary hardenability. The mechanical properties of Super Hy-Tuf steel, as determined by the producer, seemed to line up in an attractive array.

Manufacturing routine was as follows:

1. Pancake upset forged.
2. Normalized at 1700° F. and air cooled.

3. Annealed at 1400° F. and furnace cooled.

4. Machined.

5. Austenitized for 1 hr. at 1700° F. and oil quenched.

6. Tempered at 500° F. for 1 hr. and oil quenched.

7. Retempered at 500° F. and oil quenched.

8. Chromium plated.

9. Hydrogen embrittlement relieved at 500° F. for 1 hr. and oil quenched.

The hardness as a result of this processing was Vickers pyramid number 634 at 30-g. load, which corresponds to a tensile strength of approximately 290,000 psi.

The first five hooks were broken in tension, and they failed at loads of 29,000, 28,000, 27,000, 26,500, and 22,500 lb. Except for the one hook which failed at 22,500 lb., these tensile strength values were approximately one third greater than the average breaking load of the hooks previously in production, and were directly proportional to the increased ultimate tensile stress of the steels. A review of the test records for the old production disclosed that 20,000 lb. was the average strength, and the variation was about ±5%. The one hook of the new lot which failed at a comparatively low value (22,500 lb.) indicated a deficiency in processing; the range 22,500 to 29,000 lb. indicated a process "out of control".

In an attempt to correct this condition an additional low-temperature heat treatment was performed on the remainder of the hooks. The sequence was as follows:

1. Retempering at 550° F. for 4 hr. and oil quenching.

2. Hydrogen embrittlement relief at 375° F. for 8 hr.

3. Austenite stabilization at 250° F. for 24 hr.

The tempering at 550° F. softened the hooks somewhat, and the eventual hardness was Vickers 614, corresponding to about 283,000 psi.

After the additional treatment, three hooks were pulled to destruction with the following results: 28,125, 27,880, and 27,100 lb.

Fatigue tests of the hooks in this condition gave endurance life about double the number of cycles before failure in comparison to the hooks tested before the heat treating schedule in three steps just mentioned.

Finally a series of hooks made of Super Hy-Tuf with the complete heat treatment were prestressed by a load of 19,000 lb. and tested in fatigue. Results of a typical set of five are 81,000, 85,000, 113,000, 157,000, and 163,000 cycles to failure.

This scatter of fatigue results at any stress range, unlike those in tensile testing, is recognized to cover a wide band and the variation of these results is, therefore, typical. The hook that failed with the least number of cycles endured over three times the acceptable minimum number of cycles for the old materials and about 2½ times the average (approximately 30,000 cycles).

In short, we had produced an aircraft part of ultra high-strength steel by a practicable commercial routine which had about 35% greater safe working load and at least double the fatigue life, yet we had not increased the size or weight.

Precautions in Fabrication

Fabrication of this steel should include the following processing steps for optimum benefit:

1. For forged parts use pancake upset forging. This technique was specified in the development contract for the test hooks. Pancake upset forging is conducive to a uniform grain flow of the steel and should be specified for optimum mechanical properties in all forged armament items where grain flow is a consideration.

2. Normalize at 1700° F. and air cool.

3. Anneal at 1400° F. (if necessary for machinability).

4. Austenitize for 1 hr. at 1700° F. and oil quench.

5. Temper at about 550° F. for 4 to 8 hr. and oil quench. Due to the extended tempering time, double tempering would not ordinarily be necessary. The tempering operation should produce a tensile strength of 280,000 psi. minimum.

6. If the parts have been chromium plated they should be relieved of hydrogen embrittlement by treatment at 375° F. for 8 hr.

7. Finally, for the stabilization of possible retained austenite, a treatment at 250° F. for 24 hr. is desirable.

It should be mentioned that the above deals with a forged section size of roughly 1.5 in. diameter. Slight modifications in this suggested processing might be necessary for larger sections.

For the aircraft designer an ultra high-strength steel can be a new-found avenue for improvement in three directions:

Safety – The load safety factor for existing configurations will be increased.

Weight-Saving and Load-Carrying Capacity – For similar section size a significant increase in load-carrying capacity will be obtained.

Cost – In many parts where increased strength is needed, it can be provided by an improved steel rather than by changing the design.

Atomic Information for Engineers and Industrialists

By the Editor of Metal Progress

A historical note outlining the difficulties in differentiating between information to be held secret lest its publication should endanger "the common defense and security" and information necessary for an engineer and businessman to know in order to put the atom to work in peacetime industry. (A 6, U 8)

CONSTANT readers of *Metal Progress* will know that the magazine has carried a good deal of information about atomic energy ever since President Truman announced the first explosion over Japan, including many pages on the "Atomic Age" quoting from official documents about international relations and such other nonmetallurgical topics. *Metal Progress* may thus take a little pride in being many years ahead of the great crops of publications, news letters, and advisory services which have recently sprung up all over the landscape. However that may be, this longer article will describe the impediments which have blocked the publication of engineering and industrial information from the A.E.C.'s operations and contractors (in distinction to the steady flow of scientific papers from staff members).

Impediments to Normal Flow

The difficulties stem from several sources, principal of which are the atmosphere of secrecy inherited from wartime operations and the requirements of national law. Secrecy (misnamed "security") prevents the editors of the important business and engineering journals from knowing what to ask for. There is practically no gossip about goings-on in the A.E.C. operations, in comparison to the free chatter which leads to so many good articles.

For example, if the editor of *Water Works Engineering* deduced from the newspaper reports that there would be a good story about fluoridation of the Cleveland water supply he could come to Cleveland and talk freely about the proposition with any official, engineer, dental expert or politician he could button-hole, inspect the entire water system, and if he could not get a story written for him he could go home and write what he wanted and print it forthwith. On the other hand, there might be a good story about the filtration of the Columbia River water for cooling the plutonium piles at Hanford, but he'd never learn about it from the public prints, he couldn't go there and inspect the plant or talk to anybody on the inside until he had proper "clearance", and he couldn't print anything in the form of a solicited article or an eye-witness report until it had been passed for publication by the A.E.C.'s Office of Classification.

While it's not impossible that an article about the purification system at Hanford could be written and published, the impediments to normal publicity are very real.

In order to get some idea of the hurdles erected by law it is necessary to turn to the legislation known as the "Atomic Energy Act of 1946", which transferred America's atomic energy property and program from military control to a civilian commission. The Commission was to be "subject at all times to the paramount objective of assuring the common defense and security", which naturally hampered the execution of one of the five major programs outlined, namely, to "permit and encourage the dissemination of scientific and technical information". The Commission was also directed to control the dissemination of restricted data, the latter being defined as "all data concerning the manufacture or utilization of atomic weapons, the production

of fissionable material, or the use of fissionable material in the production of power".

In view of the immediate importance of reorganization of a rapidly dissolving staff and then producing an overwhelming stockpile of bombs, it was not surprising that the dissemination of information got little attention for quite a while after the law was passed. Within a year, however, plans were formulated for a 50-volume National Nuclear Energy Series to summarize the physics and the other scientific aspects of work done by the Manhattan Engineer District. A Declassification Guide was also prepared in conjunction with Canada and England, our wartime associates in the bomb program, and a board of "senior responsible reviewers" appointed.

However, the Commission felt that American industry should take a more active interest in this civilian-managed program and appointed a group of prominent industrialists with James W. Parker, president of Detroit Edison Co., as chairman. After 14 months of study and deliberations this group reported that burdensome security regulations would make it very difficult for any industrial executive to plan any important program within a private industry. This Group also said there was a "vast amount of nonsecret information of potential value to industry buried in the files of the Commission".

Advisory Committee on Information

One result of this pronouncement was the appointment of a fairly large advisory committee on information for industry. Its chairman was S. D. Kirkpatrick, editorial director of *Chemical Engineering*, and its members were editors of engineering and industrial magazines or representatives of large engineering societies. Its duty was to ferret out this "information of potential value to industry" and recommend specific items for declassification and release for publication. The Editor of *Metal Progress* was a member of this committee and of several of the small working groups which went to the various A.E.C. operations, saw what was going on, interviewed the operating officials, and examined the documentation. Quite a job, all in all!

Actually these studies in 1950 and 1951 found no vast sore of industrial information which could be released, as reported by Mr. Parker's group. Indeed the debt was the other way around: The bomb program took most of its unit operations from peacetime American industry — also the materials and methods of construction, management and personnel techniques. Due to the preoccupation of A.E.C. operations at that time with explosive manufacture, most of the engineering and industrial operations were in the "restricted" category as defined by the law.

Even so, inspection at each site yielded perhaps a score of topics worthy and capable of publication, but little came of it principally because there was no one whose job it was to see that adequate stories were written. This situation persisted even after late 1952 when authority was given the various contractors to employ the necessary information specialists. The reasons were various: Since the authority was permissive rather than mandatory, certain contractors whose traditional policies leaned toward secrecy rather than the open door simply did nothing. At some other sites the "information specialist" found all his time taken up by public relations and local doings. Again, those who made a sincere try were handicapped by the heritage of "security".

Lastly, engineers (in contrast to scientists) are not given to literary composition; there was no steady flow of articles by the originators and participants of noteworthy engineering or management programs. Even the evils of wartime compartmentalization reappeared. Bill Jones at Argonne did not know that Frank Smith at Brookhaven or Jack Thompson at Oak Ridge was working on important aspects of his current problem — which, as a matter of fact, might already have been practically solved in an industrial plant in Pittsburgh. Expensive and needless troubles with welded equipment appeared at Location A which did not occur at Location B. To combat this situation (theoretically, everything known and recorded at Location A should have been available at Location B), a classified *Journal of Metallurgy* was established, and periodical meetings of metallurgists and of welding engineers drawn from the country-wide operations were held.

It would appear that any scheme which fences off outsiders also fences in the insiders!

Growing Industrial Interest

Meanwhile, a sizable industrial interest had arisen outside the fence. Several firms were manufacturing the special instruments for uranium prospecting and for safe operation of highly radioactive devices. Others were building all sorts of handling equipment. Still others were envying the access which the A.E.C.'s contractors (all private concerns) had to the inside dope. Vast experimentation (and sizable use) of the byproduct radioactive isotopes for controlling

processes, for medical and agricultural use, and for pasteurization of foods was under way.

Best of all, four groups of public utilities late in 1951 decided they wanted to take a close look at atomic energy for electrical generation (a "restricted" field, according to American law, but not according to British or Canadian practice) and the Atomic Energy Commission "cleared" over 100 men on the four study teams for access to all pertinent information. (The Commission had already spent, and continued to spend, great sums on the design of engines for military aircraft and for submarines, and had built an elaborate testing station in Idaho for studying the performance of constructional parts and elements in intense neutron flux – the first of its comprehensive 5-year program on power development.)

The final reports of these study teams were true engineering documents, but were labeled "classified" until the A.E.C.'s Advisory Committee on Information for Industry was able to prepare a version which was declassified. (It was summarized in *Metal Progress* for August 1953.) Each team came up with a different design (30 or 40 alternatives are available). Better, each came up with a recommendation that their sponsors appropriate anywhere from 40 to 80 million of their own dollars and get going immediately on a sizable central power plant. It was none too soon, for news from England (one of the four nations which can manufacture its own fuels, U^{238} and Pu) revealed a program for building several large power reactors by 1960.

In this way, and despite the rules and regulations which hedged out the American public, some engineering information about the industrial applications of atomic energy was becoming available to some Americans who had a "need to know", a common phrase of bureaucracy*.

The official view, as expressed by Commissioner Murray late in 1953, was that the U.S.S.R. might "capitalize for war on our reactor ideas and technology"; otherwise all reactor data could be immediately published. It was apparent that much commercial use of atomic energy for heat could not occur under existing restrictions; nevertheless the power industry – a large segment of American private enterprise – was asking for the engineering information held by the Commission and a break in the monopoly which the Commission had on the fuel – natural uranium and fissionable material.

The New Atomic Energy Act

It needed President Eisenhower's influence to resolve the dilemma. Early in 1954 he sent a message to Congress recommending changes in the Atomic Energy Act enabling the A.E.C. to cooperate with friendly allied nations, to distinguish sharply between information about weapons (which should be held by the Defense Departments, anyway) and the harnessing of atomic power, and to break down the barriers preventing transfer of information between governmental departments and contractors' personnel.

In fact a new "Atomic Energy Act of 1954" was passed by the Congress shortly thereafter. Without changing the general policy, the new act provided for the above recommendations and also permitted the Commission to lease or loan fissionable material for civilian uses.

It also gave permission to establish a new category of information. Acording to the old Act, a document was either black or white; it was stamped "Classified" or "Unclassified"; it could not be published or it could. Now there can be an intermediate or gray area, intended to hold all information useful to a power plant engineer, and which can be examined without much preliminary red tape by approved persons or employees of licensed firms. This leaves the matter of publication just where it was, except for the new requirement for continuous review of the status of existing documents.

The first such review has just been completed by a team of 35 scientists and engineers from various A.E.C. installations. In 11 weeks this team reviewed 30,772 classified documents; 10,916 were declassified; 8,573 were labeled "con-

*Here let me put in a footnote rejecting the idea that any man, even a governmental official, can decide *who* needs to know. Bear with a personal anecdote:

Late in World War II an ASMember named Arthur Reardon called on the Editor and presented the official thanks of the Director of Munitions for the Commonwealth of Australia for publishing an article in one of the very early issues of *Metal Progress*. It was really a rather elementary article, entitled "Why Did That Spring Break?" Reardon's story was that springs in the recoil mechanism of field guns were breaking after a few dozen rounds; the spring slipped over a pin and into a cylinder, so its dimensions were fixed; every logical heat treatment of available alloy wire that they tried did not lengthen its life.

The *Metal Progress* article told him what to do: Make the spring of round-cornered square. "The Japs didn't get Port Moresby," said Reardon.

Who could have predicted a dozen years earlier that he, over in Australia, would have a "need to know"?

fidential" and so are in the gray area; 5,583 retained their "classified" status; and 5,700 were labeled "secret" for their relationship to military propulsion reactors or to weapons.

The Day of Conferences

Just about this time American engineering and scientific societies had begun to receive generous cooperation from the A.E.C. in arranging technical programs on various topics. The earliest notable one was the conference held by the American Institute of Chemical Engineers at Ann Arbor in the spring of 1954. Other cooperative efforts attempted to collect and present all available information on a specific subject – notably the A.E.C.-A.S.M. Conference on Beryllium in Boston, whose proceedings were expanded into a comprehensive book about the metal. Business organizations like the National Association of Manufacturers, the Atomic Industrial Forum, and the National Industrial Conference Board came forward with meetings on atomic power and industrial cooperation – valuable not so much for new information as for the evidence that American industry was really anxious to get on the band wagon.

For 10 years a steady stream of *scientific* papers had been issuing from the A.E.C. laboratories and sponsored researches. (Scientists are prolific writers, and the Declassification Guide had been set up on the basis that *science* could be talked about, but that *engineering* should be kept secret; also that metallurgy was engineering, not science.) Copies of all of these declassified documents have been sent to nearly 50 depository libraries scattered throughout the United States where they are available to the public for reference. *Nuclear Science Abstracts* is issued biweekly to summarize these reports and other papers in scientific journals here and abroad.

It should be obvious that a major job of screening, critical appraisal and consolidation of this flood of material is a necessity. The Atomic Energy Commission itself has started on this work in the publication of three important volumes by Samuel Glasstone; Source Book on Atomic Energy (1950); The Elements of Nuclear Reactor Theory (1952); and Principles of Nuclear Reactor Engineering (1955). Also a notable book on Zirconium by Lustman and Kerze was printed in 1955, as well as a Liquid Metals Handbook (1952) with even larger supplement in 1955. Another book on thorium should result from the A.E.C.-A.S.M. conference in Cleveland at the National Metal Congress next October.

The new Atomic Energy Act of 1954 was hardly passed when plans began for the Geneva Conference on the Peaceful Uses of Atomic Energy. It had many useful byproducts, not the least being the publication of information which had been kept from Americans – and in considerable quantity, too, for at Geneva the Americans tried to be pre-eminent. Large numbers of papers on physics, geology, chemical processing, use of isotopes, and biological effects of radiation were written at the behest of the A.E.C. and presented by our official delegates. Many of the documents were summaries of published papers, but much new material was divulged.

For example, Vol. III of the *Proceedings* at Geneva has to do with power reactors. Eighteen of the 31 papers are by Americans – and they are good, notably the ones about the Shippingport pressurized water reactor well along toward completion, and the sodium-cooled reactor under construction by Atomics International (North American Aviation). These are model engineering articles in all senses of the word.

The long campaign to release engineering information to American industry seemingly is at last getting some results. And in high time, for the power plant programs are gathering steam.

Atomic Power

Aside from a program by the Atomic Energy Commission to build and test ten reactors of various designs and sizes (including the abovementioned 60,000-kw. plant partly financed by Duquesne Light Co. at Shippingport, near Pittsburgh), no less than 15 atomic power plants are in process of design by various groups within the public utilities field or proposed for completion between 1957 and 1962. These plants will cost over a half billion dollars, and generate nearly 1,000,000 kw. of electrical power.

Before these plants are on the line some very difficult metallurgical problems will have to be solved. Their outlines have been given in several articles in *Metal Progress* during the past two or three years. As John P. Howe (a member of the A.E.C.'s Board of Senior Responsible Reviewers, by the way) remarked in his report of the Geneva Conference in *Metal Progress* for January:

"Even nuclear physicists concede that the future of atomic power depends on the work of the metallurgist and materials engineer. It is not unlikely that – at least in the free world – these problems will fall upon the shoulders of a relatively few individuals."

It is a challenge worthy of our best men.

The Columbium Shortage Is Over!

"Electromet" Ferrocolumbium

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The development of high-speed aircraft has produced a wide-spread demand for high-temperature alloys containing columbium.

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Columbium is added to austenitic chromium-nickel stainless steels to prevent intergranular corrosion and improve strength at high temperatures. A columbium addition of 10 times the carbon content will stabilize stainless steels at temperatures of 800 to 1600 deg. F., thus preventing impairment of corrosion resistance and physical properties. In the high-temperature alloy field, 0.2 to 4.0 per cent columbium will preserve the strength of super-alloys during long exposures to temperatures up to about 1550 deg. F., or slightly higher.

ELECTROMET furnishes columbium in two forms: ferrocolumbium and ferrotantalum-columbium. Ferrocolumbium contains 50-60 per cent columbium, while ferrotantalum-columbium contains approximately 40 per cent columbium and 20 per cent tantalum. Both of these ferro-alloys are available in a number of crushed sizes and give a 90 per cent recovery of columbium.

For further information about ELECTROMET columbium alloys, please contact the nearest ELECTROMET office listed below.

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Correspondence . . .

Another Jet Engine Alloy

PITTSBURGH

In the data sheet published in the January issue of *Metal Progress* which listed the strength of jet engine alloys, the properties of Greek Ascoloy, A. M. S. 5616 B, were omitted. Since the alloy is currently being used in compressor wheels and blades of the J-57 engine, its properties should have been included with those of other jet engine alloys.

The results of stress-rupture tests recently conducted at Firth Sterling, Inc., on notched and unnotched specimens are shown below. The notch was 0.0275 in. deep in 0.180-in. diameter specimens; its root radius was 0.005 in. and the included angle was 60°. All samples were oil quenched from 1750° F. and aged at 1200° F. for 4 hr. before testing.

The nominal composition of Greek Ascoloy is 0.15% C, 13% Cr, 3% W, 0.2% Mo and the balance iron.

W. L. HAVEKOTTE
Manager, Cermet Research
Firth Sterling, Inc.

Nomograph for Strain Conversion

PITTSBURGH

We have found the nomograph shown in the data sheet, p. 80-B, useful in the evaluation of ductility in tensile tests. With it, it is possible to convert from uniform strain to natural strain, reduction in area to natural strain, and uniform strain to reduction in area. Necking strain may be evaluated from measurements of uniform strain and reduction in area. All conversions assume a material with constant value.

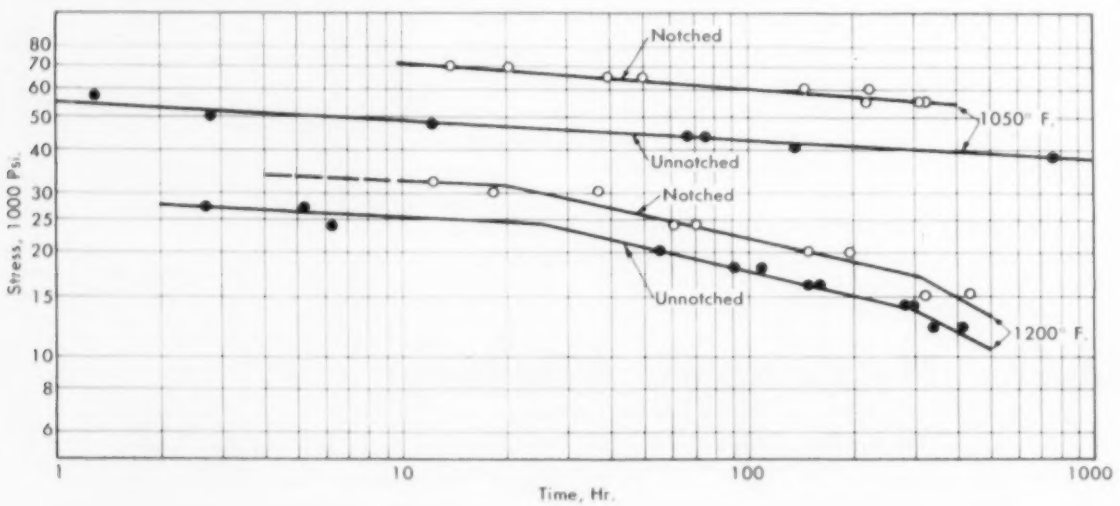
Uniform strain is defined as the plastic strain before necking occurs in a tensile test. To convert from uniform strain to natural strain, read from the lower to the upper horizontal scale; for example, 50% uniform strain equals 0.41 natural strain.

Natural strain is obtained from a measured value of reduction in area by reading from the left vertical scale to the right vertical scale. A reduction in area of 60% is equal to 0.91 natural strain.

The 0% necking strain line is used to convert uniform strain to reduction in area. Enter the chart with a known value of uniform strain and move up to the first sloping line. Reduction in area is read from the left scale at the intersection; for example, 30% uniform strain equals 23% reduction in area.

To evaluate the necking strain which occurs between the end of the uniform strain and fracture you

Stress-Rupture Properties of Greek Ascoloy (A.M.S. 5616 B)



Pacific FLOODAIRE FURNACE MEETS *ALL FOUR* REQUIREMENTS OF *PROFITABLE* PERFORMANCE...

OPERATES 8 TO 12 HOURS A DAY...YEAR AFTER YEAR...WITH NO MAINTENANCE... for Holister Coil Spring Manufacturing Company!

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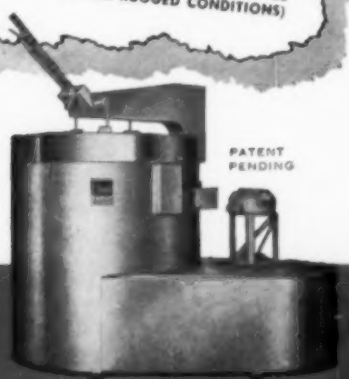

FOUR REQUIREMENTS ARE VITAL for the profitable operation of a heat treating furnace—and Holister Coil Spring Company found all four in their Pacific Pit Type Floodaire Furnace.

First, *accuracy* is essential—particularly in making springs which must perform to rigid customers' specifications. Here, the Floodaire is built to stay within ±5°F. A recent government temperature survey at Holister showed *less than ±2°F. variation!*

Speed is important to profitable performance, too. And Pacific's exclusive Floodaire design brings work up to heat fast, due to its unique element location and air circulation pattern. The high volume circulation of air also provides unusual heating uniformity.

Versatility...according to Holister, they can use the Floodaire for tempering or aging *anything* within its size range. This is another necessity when heat treating involves work which varies from load-to-load.

And of course, a furnace must be *trouble-free*—with no costly down-time or delays of customers' work. This Floodaire has been operating without a single service call for over two years—and with a full 8 to 12 hour shift every day!

This installation is typical of the performance of hundreds of Pacific-built furnaces for every type of job. (Another Pacific Furnace, a Shaker Hearth type, can be seen in the photo above.) Call or write today for details on a Pacific-built furnace for your exact needs!

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Nomograph . . .

must measure both uniform strain and reduction in area. From the intersection follow the slope up and to the right vertical scale; 40% uniform strain and 50% reduction in area indicate that necking strain is about 30%.

F. Forscher
Atomic Power Div.
Westinghouse Electric Corp.

More on Statistical Techniques

Niles, Ohio

It has been called to my attention by several readers that my article in the February issue of *Metal Progress* should have had more explanation concerning Tables III and IV.

It should have been stated that the model consideration in this experiment was a "random" of Model III. This model was used since the times and temperatures used were selected from a known distribution of times from 1 to 8 min. and of temperatures from 70 to 170° F. The times and temperature were not present or fixed, but rather were randomly selected from known distribution based on previous experience. Inferences were drawn upon these known limits of time and temperature.

Chester R. Smith
Mallory-Sharon Titanium Corp.

Micro-Examination of Barium Titanate

Schenectady, N.Y.

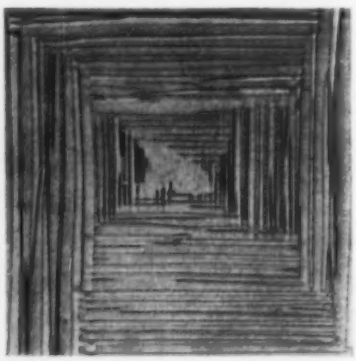
Until recently, micro-examination of ceramic materials has been confined to transparent sections and the original or fractured surfaces. We have developed a simple technique for revealing the internal microstructure of the ceramic, $BaTiO_3$, which is similar to that used for metals. A surface which is representative of the true structure may be prepared in about 15 min. with the same cloths and abrasives used for conventional metallographic preparation.

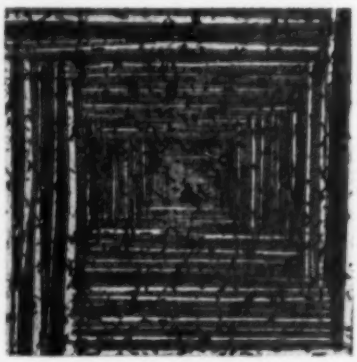
The lump sample is sectioned and

Metallography . . .

mounted in plastic or a supporting clamp. The surface to be examined is then abraded on papers of 240, 400 and 600 grit using water as a lubricant. Evidence of chipping caused by the coarser papers should be completely removed before leaving the 600 paper.

Rough polishing is done on a felt wheel using coarse Precisionite and water. A good quality cloth with a moderate nap is used for final polishing. A fine abrasive (fine Precisionite) and water are used for





The Black "Defects" in the Top Micro Are Caused by Improper Grinding. The true structure of a single crystal of $BaTiO_3$ is shown below. Etched in dilute HF-HNO_3; 100×

the first two minutes of final polishing. For the last minute a small amount of a dilute acid solution (water plus ¾% of a mixture consisting of one part concentrated HF and two parts concentrated HNO_3) is added to the polishing medium on the wheel and the sample is rotated with light pressure to remove any flowed material which may have formed. This produces a surface with a slight relief polish and a very deli-

Metallography . . .

cate etch of the grain boundaries.

The acid solution described above is also used as the etchant. We obtain best results by swabbing the specimen for 10 sec., washing in warm water and drying in an air jet.

The two most important steps are the final grinding and the etch-polish. If too little material is taken off in the last grinding operation, the surface appears full of small cracks, as shown in the top micro on p. 100, while careful grinding results in the clear surface shown below.

D. KONTOLEON and J. TOMLINSON
General Electric Co.
Research Laboratory

Where Does the Nitrogen Come From?

PITTSBURGH

When I read the article "Air as a Nitriding Gas", by Reed Knox in the November 1955 issue of *Metal Progress*, I recalled similar observations that I made several years ago. The results were published in *Metal Progress* in April 1942 under the title "Auto-Nitrification of Steel as it Scales".

Briefly, this article reports some experimental work done to explain the high nitrogen contents found in some nails uncovered in the ruins of St. Pierre in Martinique. Examination of several of these nails had shown nitrogen contents varying between 0.026% and 0.108%. The nitrogen content of the scale surrounding the nails was low (0.005%). Of several possibilities for explaining the source of the excess nitrogen, the most plausible seemed to be that "the concentration of nitrogen in the nails was increased by preferential oxidation of iron and other elements which decreased the volume of metal without loss of total nitrogen".

It was postulated that nitrogen will not readily diffuse through an appreciable continuous layer of scale and therefore, during high-temperature oxidation, the total nitrogen remains in a decreased amount of metal with resulting increase in concentration. To support this reasoning, samples of a ¾-in. square steel bar were heated in an open furnace for 24 to 72 hr. at

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APW

ENGELHARD INDUSTRIES

Nitrogen . . .

2100 to 2200° F. In 24 hr. the surface nitrogen content increased from 0.0113 to 0.0166%. After 72 hr. the surface nitrogen content reached 0.0198%.

To determine whether atmospheric nitrogen could have contributed to the nitrogen pickup observed during oxidation, the experiment was repeated in a carbon combustion furnace using an atmosphere of pure oxygen. The flow of oxygen was regulated to prevent excessively rapid oxidation of the specimen. After 72 hr. in the oxygen atmosphere at 2100° F., the surface nitrogen content increased from 0.0118 to 0.28%.

These data indicated that, during high-temperature oxidation, a large part of the original nitrogen in steel diffuses into the remaining metal, rather than escaping into the scale. This mechanism was termed "auto-nitrification".

While I do not mean to contradict the statement that steel will absorb nitrogen from the air at high temperatures, I want to point out that, under certain conditions, an extraneous source of nitrogen may not be necessary to produce the results found by Knox. It seems likely that the rate of oxidation cannot exceed the rate of nitrogen diffusion if a nitrogen pickup is to be obtained. As I mentioned above, the experiment with oxygen required careful regulation of the oxygen supply in order that the sample would not be completely oxidized. In the observation Knox reported, it seems possible that the rate of oxidation in the cracks of the ingots was slower than on the sound surfaces. Thus, it is possible that there was sufficient time for the nitrogen to diffuse into the steel at a faster rate than iron was oxidized.

G. H. Enzian
Assistant Director
Technical Services Div.
Jones & Laughlin Steel Corp.

Conshohocken, Pa.

The experiment using a pure oxygen atmosphere has proved that auto-nitrification can take place when steel is heated at 2100° F. and I appreciate the suggestion that this is the process I have observed occasionally in defective mild steel

Sperry

ultrasonic inspection news

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Through the development of standard-unit ultrasonic inspection equipment and auxiliary components, Sperry makes it possible to assemble automatic or semi-automatic SIMAC systems at greatly reduced costs. The basic unit is the Type UW Reflectoscope which can be combined with auxiliary test equipment to meet individual flaw detection requirements. Shown above, the UW Reflectoscope is being used to inspect an immersed aircraft forging which has contours requiring the use of a precision (PH) search unit positioner in order to control the direction of the ultrasonic beam projected into the part.

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Nitrogen . . .

slabs. The same suggestion was made to me last year by Dr. W. Oelsen, the noted German physical chemist. I believe he had in mind the concentration of copper at the surface of copper-bearing steels during high-temperature oxidation. The experiments I reported in *Metal Progress* were partly inspired by Dr. Oelsen's suggestion. If "auto-nitrification" caused all the increase in nitrogen found after high-temperature heating in air, the final nitrogen content could not exceed the product of the reciprocal of the fraction of the original metal remaining after oxidation and the original nitrogen content of the specimen. In other words, if half of the original metal remained after oxidation, then the average nitrogen content in this remaining metal could not exceed twice the original nitrogen content. The final nitrogen in my experiments was much too great to be accounted for by auto-nitrification alone. The nitrogen in one specimen increased from 0.002 to 0.015% as a result of heating in air for 3 hr. at 2515° F., yet its weight loss was only 48.7%.

Other experiments at temperatures ranging from 2000 to 2400° F. yielded results in support of my original conclusion. About 24 nitrogen determinations were made after heating, and only with specimens heated at 2000° F. is there serious doubt that the nitrogen increase was greater than could be explained by auto-nitrification alone. Chips used in the nitrogen analyses were obtained by drilling all the way through the specimens with a ¼-in. drill. Although it is possible that the nitrogen found in the steel after heating was not uniformly distributed throughout the mass, the analytical results give at least qualitative proof that nitrogen absorption takes place when mild steel is heated above about 2200° F. in air. The small specimens I used were heated on steel blocks with about one-third the area of a specimen in contact with a block surface covered with mill scale. A continuous jacket of heavy scale enclosed both blocks and specimens when they were removed from the furnace but no difficulty was encountered in separating any of the specimens from the blocks.

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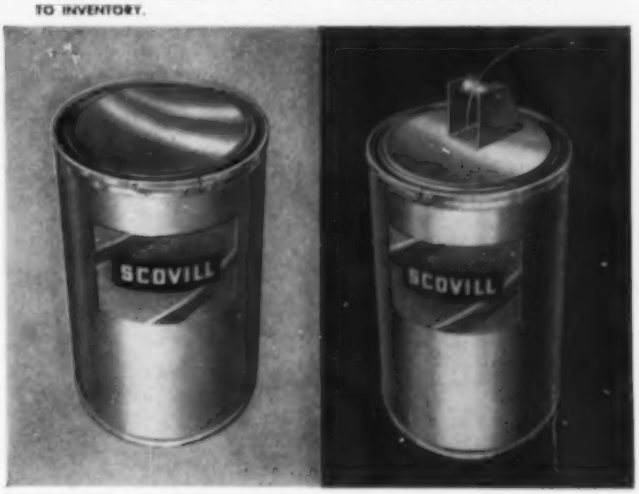

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Nitrogen . . .

out a rigorous series of experiments which would establish the relative contributions made by nitrogen absorption and auto-nitrification to the increase in nitrogen found in small steel specimens after heating in air at various high temperatures. In this connection it would seem wise to reduce an entire specimen, after heating, to chips and then to mix the chips thoroughly before analyzing for nitrogen. This procedure should obviously minimize the chances of getting analytical results which would lead to false conclusions because of segregation of nitrogen within the specimen.

REED KNOX, JR.
Research Metallurgist
Alan Wood Steel Co.

Magnaflux Indications of Quality

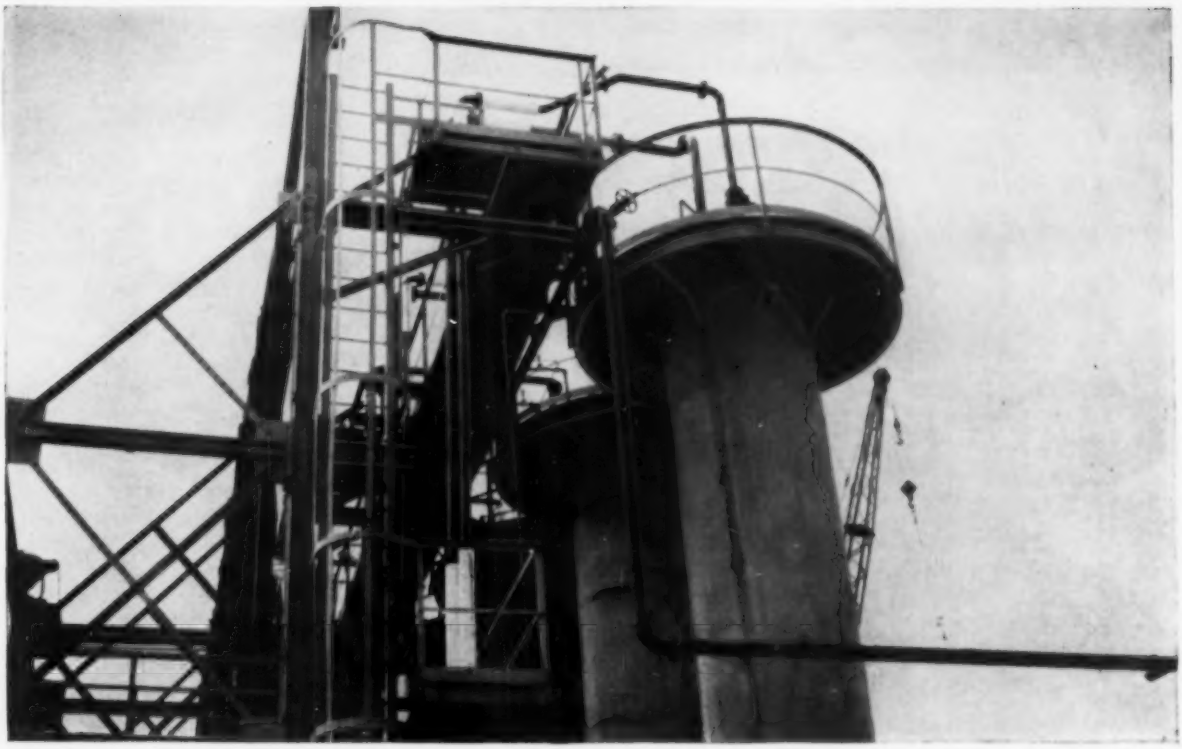
CANTON, OHIO

We should like to reply to the several criticisms given in the March issue of *Metal Progress* by C. F. Comstock in his digest of the paper entitled "The Effect of Deoxidation Practice and Hot Work Reduction on the Occurrence of Magnaflux indications in E 4340 Steel".

He indicated that there was definite partiality for the calcium-silicon deoxidized heat and that maximum difference in favor of that heat was shown only by selected forged 4-in. round Magnaflux tests. He further states that had rolled 4-in. rounds been selected the difference would have been negligible. Mr. Comstock is quite correct in his observation and a word of explanation is in order.

It has been standard practice in our plant to use 4-in. round forged tests in comparing heat Magnaflux ratings. We have accumulated considerable experience and reliance on tests made in that size and condition and have no such background of experience with rolled tests. It is customary for steel mills to use forged rather than rolled samples because of the obvious difficulty in rolling a standard size of test sample from the wide range of bloom or billet sizes that are required in production.

From a purely technical viewpoint



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Magnaflux . . .

it might have been more conclusive to compare the total Magnaflux heat ratings which were 437 F – 391 S for the calcium-silicon heat and 464 F – 498 S for the ferrosilicon heat. This comparison warrants the same conclusion but would not be as meaningful to mill metallurgists familiar with conventional Magnaflux testing procedures.

The abstractor also commented that it is falsely stated that the calcium-silicon heat gave a lower average inclusion count rating than the ferrosilicon heat. This conclusion is correctly drawn and is based not only on the tabulated listing but also on the metallographic examination of the inclusions that caused the Magnaflux indications.

Finally, the criticism was made that there was no mention in the conclusions of the superior etch results of the ferrosilicon deoxidized heat. As stated in the body of the report, etch test comparisons were quite similar and both heats would be considered to have acceptable macro-etch quality with only a slight preference for the ferrosilicon.

Any slight differences that may exist in either macro-etch or nonmetallic inclusion count are relatively unimportant to the subject matter of this paper. This, as the title clearly states, is a study of deoxidation practices relative to Magnaflux indications observed after various amounts of hot work reduction. It is impossible to predict Magnaflux quality from either macro-etch or nonmetallic inclusion count examination.

A. F. Sprankle
Metallurgical Engineer
Timken Roller Bearing Co.

Chromic Acid-Acetic Anhydride "Explosion"

Melbourne, Australia

A solution prepared from chromium trioxide and acetic anhydride has been recommended for use in electrolytic polishing of metals, but in some instances, without adequate warning of the hazard involved. In these laboratories an accident recently occurred while such a solution was being prepared. *(Cont. on p. 112)*

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Explosion . . .

A chromic acid solution was made by dissolving 100 g. of chromium trioxide in 200 ml. of water. After it had cooled to room temperature, 700 ml. of acetic anhydride was added in a very slow stream, just faster than drop by drop. The temperature of the solution rose slightly during the addition.

Having completed the addition of the acetic anhydride, the operator left the beaker containing the solution on the bench and moved a short distance away. Within about 15 sec. the solution erupted from the beaker with sufficient violence to reach a ceiling some 16 ft. above the beaker, and to fill the room with fine spray. The operator suffered superficial acid burns on the face.

Since this mishap occurred we have heard of other accidents resulting from the mixing of chromium trioxide with acetic anhydride. Metallurgists or metal finishers who might be interested in using this type of electrolyte should realize the danger.

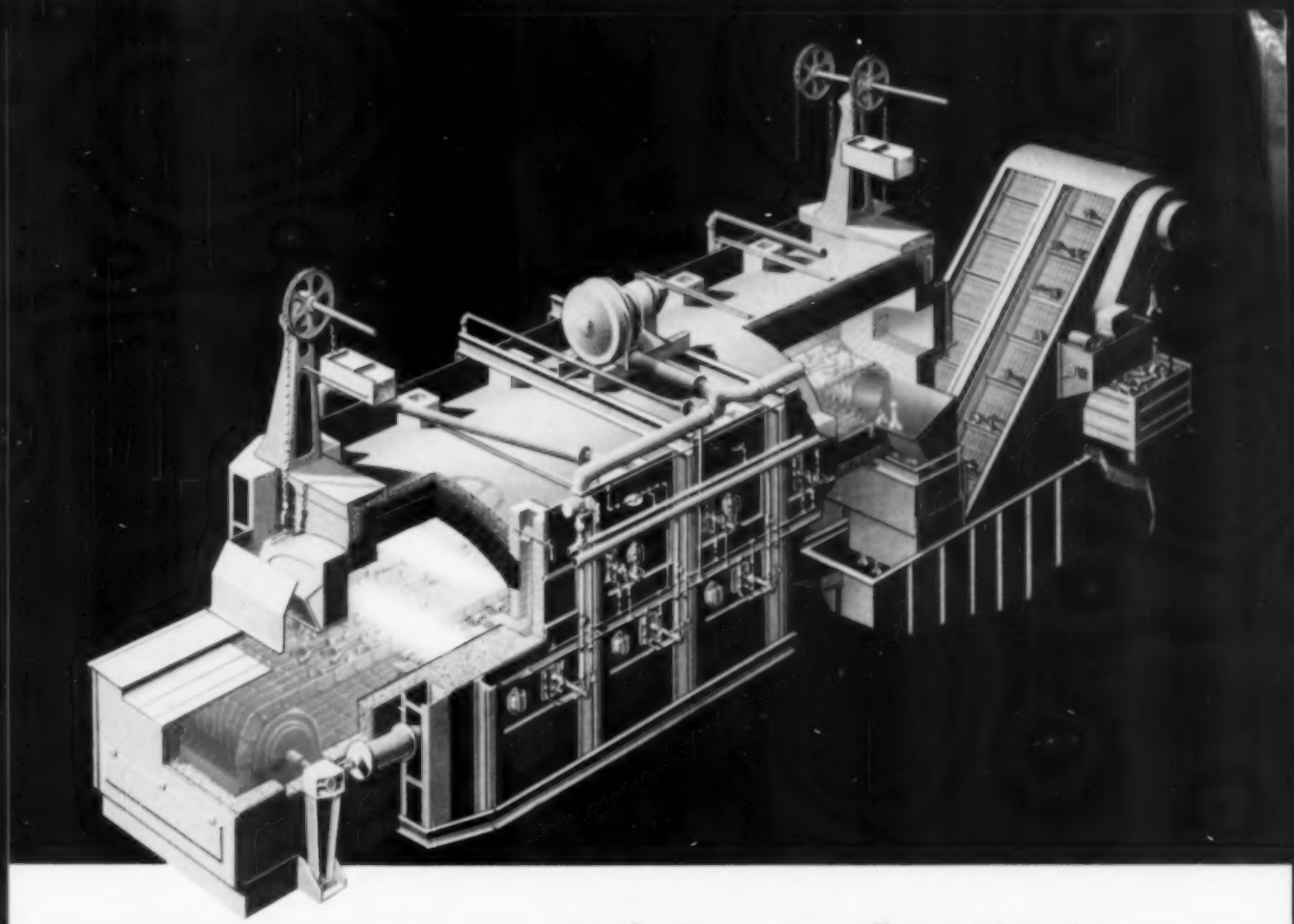
A. E. Dawkins
Chief Superintendent
Defence Standards Laboratories

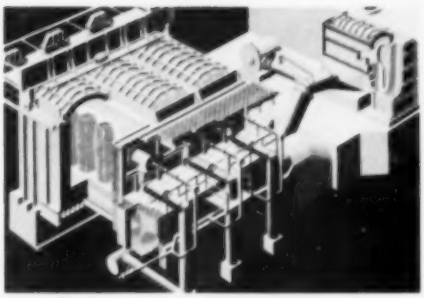
Segregates in Large Steel Blocks

Chicago

The report on "Recent Accidents With Large Forgings" in February *Metal Progress* is interesting from various aspects. Figures 4 and 5, showing parallel bands of segregate (higher alloy, higher carbon material) in one of the forgings, especially caught my attention because I have observed such conditions in some toolsteel parts of large cross section. Discussion of these findings with the toolsteel metallurgists nearly always brings forth the opinion that these cannot be considered a cause for failure, apparently because they think that such segregations or heterogeneities are normally to be expected in large blocks of metal and that they cannot be eliminated even by following the best commercial practices in melting, casting and forging.

E. J. Pavesic
Director of Research
Lindberg Steel Treating Co.





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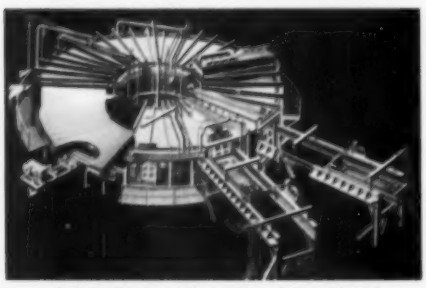

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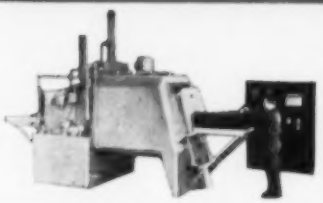

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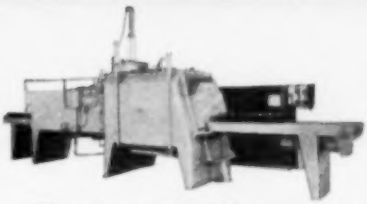

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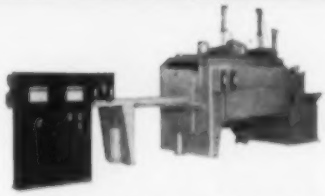

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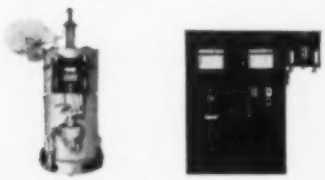

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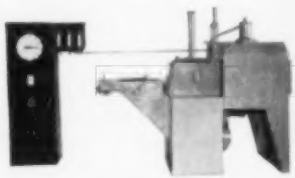

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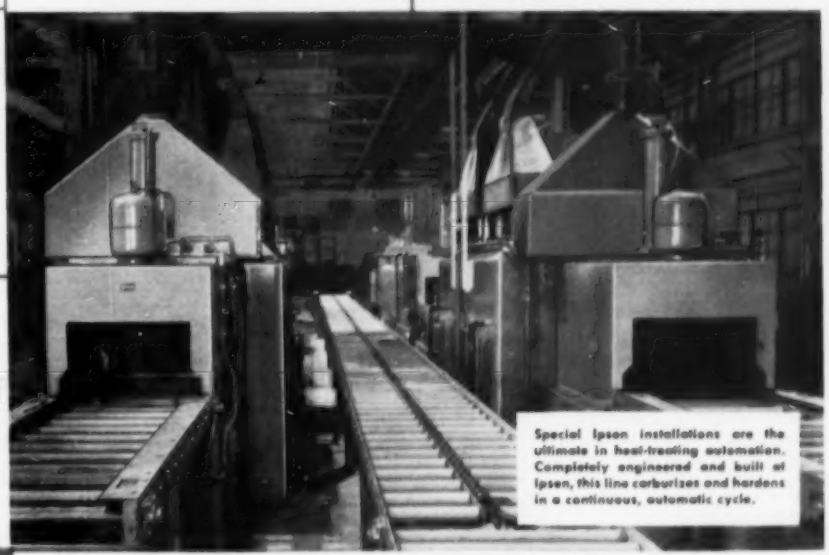

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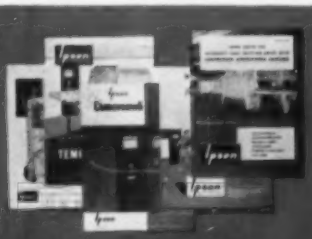

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Personal Mention

Peter R. Kosting

Born in Edinburgh, Scotland, PETER R. KOSTING received his technical education at Cooper Union in New York City, then going on to Rensselaer Polytechnic Institute for postgraduate work, getting his doctorate in chemistry in 1928. For the next four years he lived in Washington, D.C., the first half being spent as chemist in the Fixed Nitrogen Research Laboratory where he was impressed by the difficulty of the problems connected with the equipment for making ammonia. Corrosion of metals thus became his main study, and several contributions in the technical literature in those years, plus the next two as research associate at the Bureau of Standards, indicate his trend away from chemical engineering into metallurgy.

In 1932 he moved to New England and for nearly 25 years worked in the metallurgical laboratory at Watertown Arsenal, first as a metallurgist and later as chief of the chemical and metallurgical divisions. Especially during the years of World War II, Kosting was immersed in problems connected with the manufacture of field artillery and heavy guns, and in the unusual combination of circumstances at Watertown was able to observe the interaction of laboratory findings and manufacturing techniques in the production, forging, heat treatment, machining and proof testing of heavy castings and forgings. For this work he received the "Commendation for Meritorious Civilian Service" from the U.S. Government in 1944. His encyclopedic knowledge of the field is proven by a series of historical articles dealing with the development of metals and alloys for large gun tubes appearing in *Metal Progress* during 1954.

In an endeavor to coordinate more effectively the investigations at the various Army arsenals and proving grounds, as well as the large amount of sponsored research at universities and other institutes, the U.S. Department of Defense has set up an "Office of Ordnance Research" at Duke University, in Durham, N.C., and Kosting has recently been transferred there to fill the position of director of the division of metallurgical and engineering sciences.

Peter Kosting has been actively interested in the Boston Chapter, since joining the Society in 1930, serving on the chapter's executive committee for years and as chapter chairman in 1950. His other society memberships include the American Institute of Mining, Metallurgical and Petroleum Engineers, American Society for Testing Materials, American Ordnance Assoc., and the British Institute of Metals.

The Kostings (Peter married Lillian Helliwell of Washington, D.C.) are celebrating their silver anniversary this year. His hobbies, he writes, are "stamps, history, more science".

Frank Garratt recently retired as a vice-president of the Universal-Cyclops Steel Corp., Bridgeville, Pa. However, Mr. Garratt will remain as director of the corporation and serve as senior consultant to management. **John O. Rinek**, a vice-president and director, will become advisory vice-president. In an announcement of other appointments at Universal-Cyclops, **W. J. Long** has been named vice-president of sales and a director. Mr. Long has been associated with the corporation for 25 years in various sales responsibilities and was appointed a vice-president in 1949. **Walter E. Baker** has been named vice-president of operations. Mr. Baker has been associated with the corporation as a manufacturing executive and officer for 39 years. **Charles T. Evans, Jr.** has been named vice-president of technology and development.

John C. Hamaker, Jr.

JOHN C. HAMAKER, JR. has been appointed manager, research department, Vanadium-Alloys Steel Co., Latrobe, Pa. In this position, Dr. Hamaker will direct all research and development activities for the company's four steel divisions.

After graduating from the University of Michigan in 1945, Dr. Hamaker served in the Navy. He returned to Michigan for graduate work in 1947, holding the International Nickel Co. fellowship from 1947 to 1949, and in 1952 received his Ph.D. in metallurgy. During this period, he worked in the metallurgical laboratory of Rotary Steel Co. (1942), the research laboratory of International Nickel Co. (1948), and as sales engineer for Foundry Services Inc. (1950). From 1951 to 1953 he was plant metallurgist for General Iron Works Div., Stearns-Roger Mfg. Co. in Denver. In 1953 he joined Vanadium-Alloys as a research metallurgist.

Dr. Hamaker is an active member of several committees of the Pittsburgh Chapter, and is co-authoring the Metals Engineering Institute course on toolsteels. He has also been giving a number of lectures before Society chapters and will deliver the section on toolsteels in the Carolinas Chapter educational series this year. He is also chairman of the American Standards Assoc. committee on solid single-point tools.

Office with concealed piping, only the heads showing

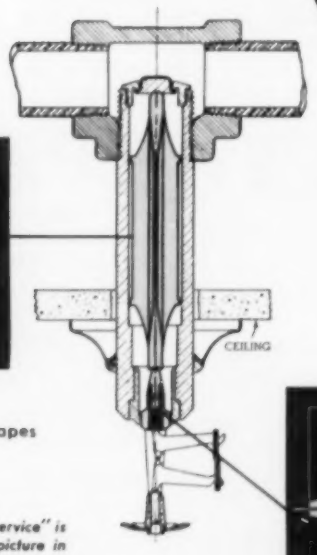
REVERE Extruded Shapes

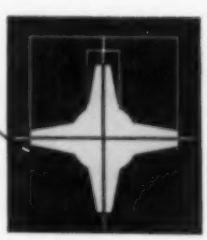
in dry pendent sprinkler heads lessen machining, save money

Some 16 years ago the Viking Corporation, Hastings, Michigan, decided to find a way to put sprinkler piping for dry pipe systems above the finished ceiling, leaving only the sprinkler heads visible. This meant designing a sprinkler head which would be free of water except when in use. Thus there would be no drainage problem, and no chance of freezing. The dry pendent sprinkler head as finally developed extends into the sprinkler pipe, where a bronze cap keeps the entire valve waterless. When a fire occurs the usual fusible element melts, two struts drop, releasing the cap and permitting water to flow.

In the original experimental work, the two struts were machined out of solid brass bar. This took time and involved the generation of a considerable amount of scrap, since each strut has four deep fins. Once the idea had proved itself, Viking came to Revere for extruded shapes, in order to save both machining and metal. So much time has elapsed since the original machining of the bar that comparative cost figures would be meaningless, but it is evident to Viking, and to everybody familiar with extruded shapes, that the saving is substantial.

Cross section of Viking Dry Pendent Sprinkler Head, and cutaway view





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Personals . . .

A. O. Schaefer, president of the American Society for Metals, has been appointed director of research at the newly formed Midvale-Heppenstall Co., Philadelphia. Mr. Schaefer was formerly vice-president in charge of engineering and manufacturing at the Midvale Co., Philadelphia.

R. R. Ruppender is now manufacturing engineer of brazed assemblies in the development department of the aircraft gas turbine division of General Electric Co., Cincinnati, Ohio. Mr. Ruppender formerly was a process and development engineer in the aircraft components division of the Ferrotherm Co., Cleveland.

G. T. Motock, formerly with Electro Metallurgical Co., Niagara Falls, N.Y., is now special assistant to the director of the aviation division of Olin Mathieson Chemical Corp., Niagara Falls, N.Y.

Richard A. Dodd has resigned from the staff of the Department of Mines and Technical Surveys, Ottawa, Ont. and is now assistant professor of metallurgical engineering in the University of Pennsylvania. Mr. Dodd is working on the development of a post-graduate course in foundry metallurgy.

Kenneth H. Carlson has been promoted to the position of technical manager, aircraft materials, at the Latrobe Steel Co., Latrobe, Pa. Joining Latrobe in 1950, Mr. Carlson was a service engineer in the company's metallurgical department before his recent appointment.

Carl Eisenwinter will represent the Metallurgical Products Co., Brookline, Mass., in northeastern Massachusetts, Maine and eastern New Hampshire. Other changes in the sales engineering staff of the company are **R. D. Lindner**, covering Connecticut and the Hudson River area of New York, **Don T. Leyland**, covering southeastern Massachusetts and Rhode Island, and **Don C. Sellar**, covering western Massachusetts.

Curtis W. Dollins is now in the mechanical properties group of the metallurgy division of Oak Ridge National Laboratory, Oak Ridge, Tenn.

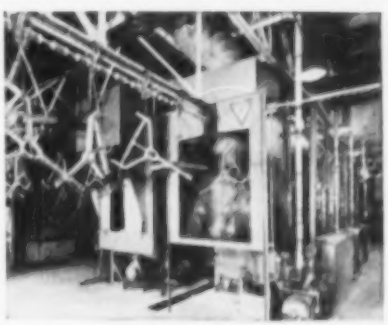
Typical of the finish on all Toledo Scales is that on this full height portable unit.

BOTH STEEL AND ALUMINUM PARTS ARE PROCESSED IN THE SAME 6-STAGE MACHINE AT TOLEDO SCALE

Steel parts are Granodized, aluminum parts are Alodized to inhibit corrosion and provide an excellent base for the high-grade finish used on these familiar products

Toledo Scale knows that the fundamental prerequisite of a good paint job is a properly prepared base material upon which the finish is to be applied. To provide this all-important base, it Granodizes most steel parts with Granodine® and Alodizes most aluminum parts with Alodine.® Granodizing is a chemical process for the treatment of iron and steel which converts metallic surfaces to a nonmetallic coating of the proper texture for inhibiting corrosion and greatly increasing the adhesion and durability of the paint finish. Alodizing performs the same functions on aluminum parts.

Both of these processes are performed in the same 6-stage machine. And both add to the long life of the Toledo finish. Perhaps these ACP processes can be used effectively in your plant. Complete data about both of them are available upon request. Write us.



Part of 6-stage machine in Granodizing Department at Toledo Scale Co.

AMERICAN CHEMICAL PAINT COMPANY, Ambler 16, Pa.

DETROIT, MICHIGAN NILES, CALIFORNIA WINDSOR, ONTARIO

CHEMICALS ACP PROCESSES

Personals . . .

Iver G. Freeman, vice-president of engineering and research at the Reed-Prentice Corp., Worcester, Mass., has been named chairman of the Reed-Prentice management committee.

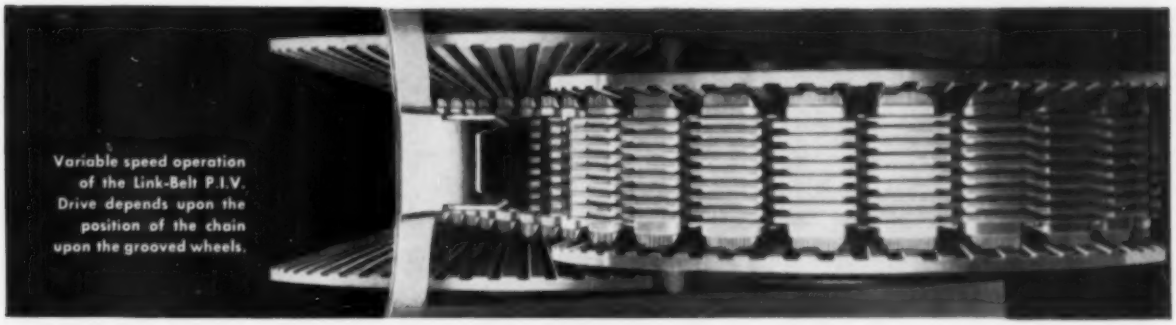
Herbert S. Burkin has left Rohr Aircraft Corp., Chula Vista, Calif., to accept a position as metallurgist in the process control laboratory at Consolidated Vultee Aircraft Corp., San Diego, Calif.

Robert B. Heppenstall has been elected chairman of the board of directors of the Heppenstall Co., Pittsburgh. Prior to his election to the board, Mr. Heppenstall served as president of the company for 16 years. Mr. Heppenstall is also president of the newly created Midvale-Heppenstall Co., Philadelphia. **John P. Roche** has been elected president of the Heppenstall Co., to succeed Mr. Heppenstall. Joining Heppenstall Co. in 1946, Mr. Roche served as vice-president and general manager of sales and in 1951 was elected executive vice-president. Mr. Roche has also been elected vice-president of the new Midvale-Heppenstall Co.

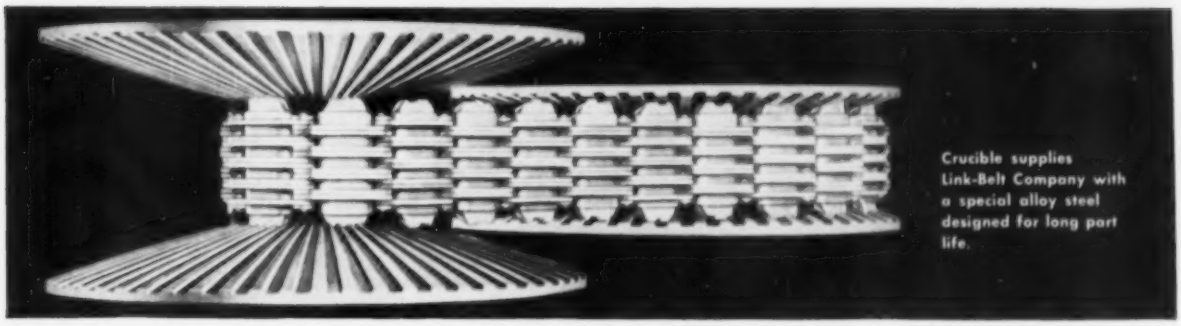
Henry H. Hausner received the Stevens Institute of Technology Powder Metallurgy Achievement Award for 1956 in recognition of his work in powder metallurgy in the field of atomic power. Dr. Hausner is general manager of the Nuclear Engineering Div., Penn-Texas Corp., New York, and also a consultant to major organizations dealing with atomic energy including Argonne National Laboratory, the Nuclear Development Corp., and the atomic power divisions of Westinghouse and General Electric Co.

Waldemar Naujoks, has joined the staff of the Drop Forging Association, Lansing, Mich., as technical director to head the Association's statistical program. Prior to his new position, Mr. Naujoks was vice-president and general manager of Globe Forge, Inc., Syracuse, N.Y.

Lewis S. Reed has joined the Dow Chemical Co. as a chemist in its central laboratory at Freeport, Texas. Mr. Reed was formerly connected with the General Electric Co. in Richland, Wash.



Variable speed operation of the Link-Belt P.I.V. Drive depends upon the position of the chain upon the grooved wheels.

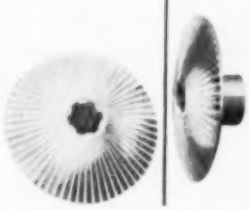


Crucible supplies Link-Belt Company with a special alloy steel designed for long part life.

these

SPECIAL ALLOY STEEL PARTS

keep Link-Belt's P.I.V. Drive on the job



Keeping production operations going at the right speed is the job of this variable speed drive unit produced by Link-Belt Company. Its operation is based on an exclusive drive chain with self-forming metal teeth, which engage with radial grooves in two pairs of cone-shaped wheels.

To make these precision wheels requires a steel that can be readily machined, will not distort, and which has high-strength. That's why Crucible furnishes Link-Belt with a special Nitriding BM alloy steel *designed* for this application. After machining the wheels are Nitrided to obtain a minimum surface hardness of 1000 Vickers Diamond Brinnel — about the hardest surface that can be obtained commercially.

When your application requires a tough, machinable, nondeforming alloy steel — call Crucible. One of our many special alloy grades may be the right one for you — or we can develop one to meet your most exacting demands. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Personals . . .

E. Scala, previously employed by the Chase Brass and Copper Co., Waterbury, Conn., is now chief of material section of the advanced development division, Avco Mfg. Corp., Stratford, Conn.

Walter A. Neisz has joined the Knolls Atomic Power Laboratory of the General Electric Co., Schenectady, N.Y., as a metallurgical engineering development specialist working in the reactor materials development section.

J. A. Succop was elected vice-president in charge of metallurgy at the Heppenstall Co., Pittsburgh. An employee of the company since 1919, Mr. Succop was appointed chief of the research department in 1926 and chief metallurgist in 1946.

Calvin C. Enderlin, formerly technical representative in the Los Angeles area for the National Can Corp., Chicago, Ill., has been appointed chief inspector of the Western division of the corporation.

Karl W. Reber, is now senior engineer on nondestructive testing at the atomic power division of Westinghouse Electric Corp., Pittsburgh. Mr. Reber was formerly a metallurgist at the Oak Ridge National Laboratories.

Martin D. Hecht has been transferred from the engineering department of the New Departure Div., General Motors Corp., Bristol, Conn., to the Los Angeles office of the corporation as supervisor of regional engineering.

K. Piekarski, formerly a metallurgist at Houdaille Ltd., Oshawa, Ont., is now engineering manager at M. N. Automation Ltd., Toronto.

Harry J. Smith is employed as chief draftsman for Mannix Gill Ltd., Calgary, Alta., consultant engineers. Mr. Smith was formerly estimator for the Canadian Kellogg Co., Ltd., Edmonton, Alta.

Alfred L. Gostow was recently appointed general manager of the Forge and Foundry Div. of the Chrysler Corp., Detroit. Associated with the corporation since 1942, Mr. Gostow served as manager of methods for the Dodge Div. during the past year.

TIN'S SPECIAL PROPERTIES IMPROVE QUALITY, CUT COSTS, IN WIDE RANGE OF NEW APPLICATIONS

And There's Plenty of Tin in Malaya, World's Largest Producer

In almost every American industry, the special properties of tin are making important new contributions today in the competitive race for product improvement. And Straits Tin from Malaya is the most widely used brand.

Tin wets metals readily, flows easily, adheres firmly and has a relatively low melting point. Tin is, of course, the key constituent of solder, and today improved equipment and processes are making solder still easier and more economical to use.

Tin has excellent antifriction qualities, conformability, and good embedding characteristics. It has long been invaluable as a bearing metal, and new tin bearing alloys — such as 20% tin-aluminum — are now producing excellent results in actual performance tests.

Tin has the property of hardening and strengthening copper twice as effectively as zinc, and provides much better resistance to corrosion.

Not only is tin one of the world's most important metals, it is now also one of our most useful chemicals. Tin compounds — as stabilizers, opacifiers, antioxidants — are currently being used in products ranging from plastics to toothpaste.

And most important of all: Tin is economical to use in any application. For just a little tin can do a lot of work.

There can never be a real substitute for tin. No other metal does so many different kinds of jobs so economically and so well. Whatever *your* product or process may be, a careful reappraisal of the properties of Straits Tin may show you new ways to improve quality and cut costs.

STRAITS TIN NEWS & NOTES

In 1955 Malaya mined 36% and smelted 43% of the free world's tin. Malaya's largest lode mine, in the State of Pahang, has 200 miles of underground workings.

★

Did you know that 500 different food products are now preserved in tin cans? And the list is steadily growing. Soft drinks and wine, for example, now come in cans. Also, of course, many non-food items — including even plastic flooring and Geiger counters. Currently, over 90% of the tin used for cans is Straits Tin from Malaya.

★

Nature stored tin ore (cassiterite) in Malaya's mountain ranges millions of years ago. Present alluvial deposits are the result of heavy tropic rains washing this ore down into Malaya's river beds and valleys. This process, of course, is continuing. Geologists say no end is in sight to Malaya's tin reserves.

★

The recently discovered method of electroplating bright tin-nickel provides for the first time an important tarnish-resistant alternate to chromium on nickel-copper. With 65% tin content, tin-nickel is both more corrosion resistant and more attractive in color than chrome.

★

The value of Malayan tin output in 1953, about $110½ million, was one-fifth the value of that year's U. S. copper production, slightly less than U. S. zinc production, and one-third more than U. S. lead.

A 20-page booklet gives an informative report on Straits Tin and its many new uses today. "Tin News," issued monthly, covers important current developments in the production, marketing and use of tin. We'll be glad to send you both if you'll send us your name and address.

The Malayan Tin Bureau

Dept. 25E, 1028 Connecticut Ave., Washington 6, D.C.

The Malayan Tin Bureau
Dept. 25E

Please send me:

☐ Straits Tin booklet ☐ "Tin News"

☐ Information on _____

Name _____

Address _____

City _____ State _____

Personals . . .

J. Robert Douslin has been promoted from plant superintendent to plant manager at the North Grafton plant of the Wyman-Gordon Co., Worcester, Mass. Mr. Douslin was transferred to North Grafton as an assistant superintendent in 1946 and made superintendent in 1949.

Edwin A. Yeo, formerly sales manager at the Pittsburgh office of Leeds and Northrup Co., Philadelphia, is now manager of the Chicago office. Prior to his Pittsburgh position, Mr. Yeo had been Cincinnati district manager for Leeds and Northrup for 16 years. **Thomas C. Bennett**, former manager of the Chicago office, is technical assistant for resale in Philadelphia.

J. B. Mohler has accepted a position as research chemist in the finishing and electrochemicals application branch of the department of metallurgical research at Kaiser Aluminum and Chemical Corp., Spokane, Wash. Mr. Mohler was a metal finishing consultant prior to his present position.

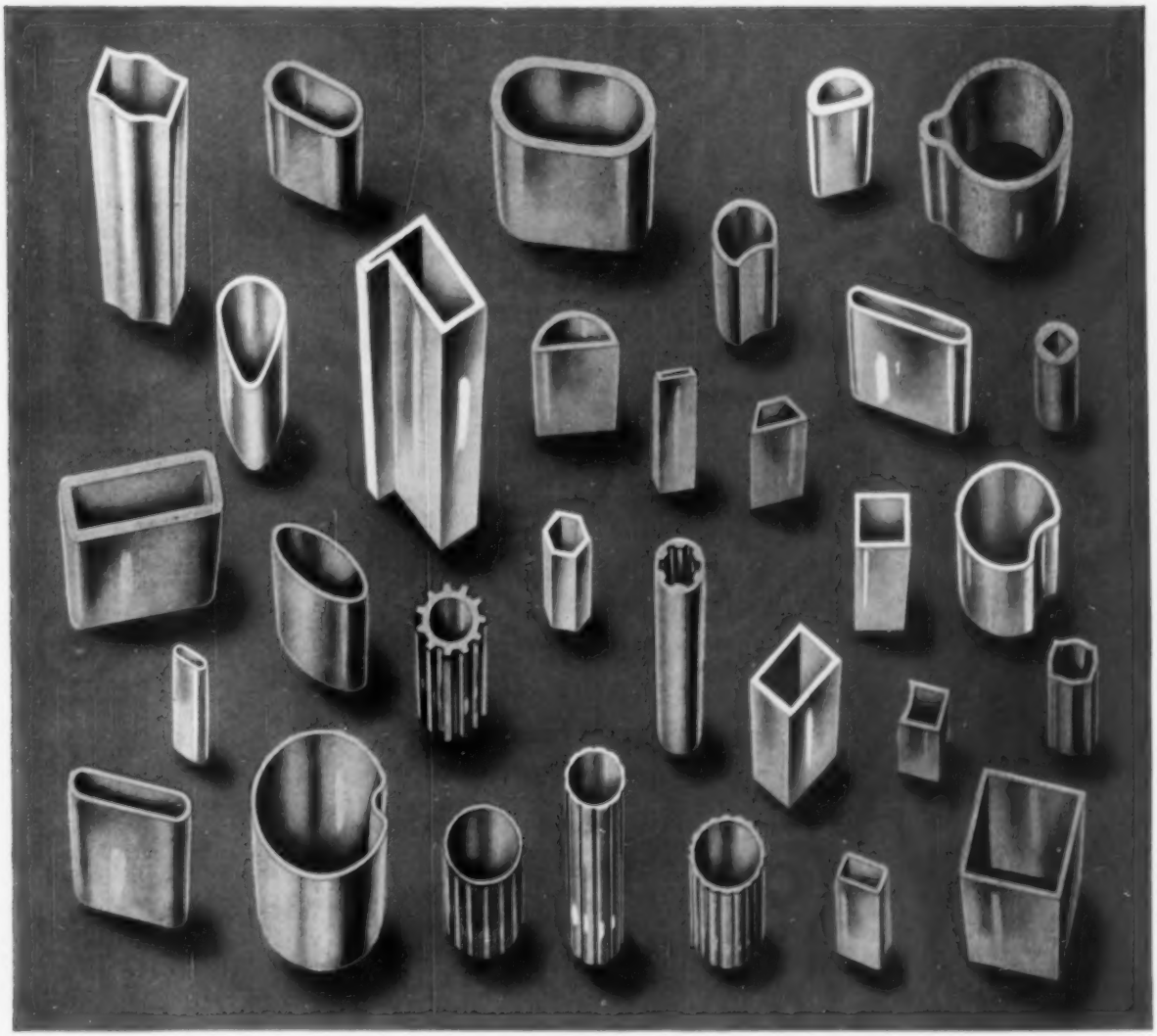
Robert C. Wayne has been appointed sales manager of the Hamilton Foundry and Machine Co., Hamilton, Ohio. For the past seven years, Mr. Wayne was employed as advertising and sales promotion manager of the industrial division of Surface Combustion Corp., Toledo, Ohio.

William W. McCulloch is now sales manager of the special products division of American Cast Iron Pipe Co., Birmingham, Ala.

James M. Copeland recently was named senior project metallurgist at the metallurgical laboratory of International Business Machines Corp., Endicott, N.Y. Joining IBM in 1951 as a technical engineer, Mr. Copeland last held the position of project metallurgist.

John H. Hull has been promoted from plant metallurgist to chief metallurgist at the North Grafton plant of the Wyman-Gordon Co., Worcester, Mass. Joining Wyman-Gordon in 1947, Mr. Hull was transferred to the North Grafton plant in 1948 and was appointed plant metallurgist in 1951.

A SHORT CUT TO A FINISHED PRODUCT



YOU NAME THE TUBE SHAPE AND THE METAL

Our specialized facilities and stock tools can save you time and money

Special-shape seamless tubes in straight lengths, or cut into short pieces, can save several steps in arriving at a finished product—can save you material and many direct labor costs. The American Brass Company's French Small Tube Division has turned out thousands of tubes in special shapes up to ¾" O.D. A variety of stock tools is available to save fitting-up charges.

For consumer products: Some special tubes are produced to the accepted commercial tolerances and finishes for such applications as electric fixtures, furniture ferrules, heat exchangers, radiator tubes, refrigeration controls, hardware, jewelry, automatic pencils, and a host of others.

High precision products: Many are made unusually accurate in I.D. and O.D. dimensions, with specially cleaned inside and outside surfaces, for parts for control instruments and for other scientific and industrial equipment.

Wide choice of metals: Special-shape tubes are available in copper, brass, bronze, nickel silver, special copper alloys, and aluminum – furnished in straight mill lengths or accurately cut to your specifications.

For action: See your American Brass Company representative or send in a sample, drawing, or description, together with the quantity you need, the metal, and other pertinent data. Address: The American Brass Company, French Small Tube Division, Waterbury 20, Conn.

ANACONDA®
SPECIAL-SHAPE TUBES

Personals . . .

Sidney D. Tannenbaum has resigned as senior metallurgist at Consolidated Vultee Aircraft Corp., Fort Worth, Tex. and accepted a position as technical engineer at the aircraft gas turbine division, General Electric Co., Cincinnati, Ohio.

Robert B. Boswell, formerly supervisor of production metallurgical control in the engineering division of Chrysler Corp., Detroit, has been appointed divisional chief engineer of the newly organized forge and foundry division of Chrysler.

Daniel E. Lehane has been named manager of sales engineering of the Chromalloy Corp., White Plains, N.Y. Prior to joining the company, he was sales engineer in the New York office of the Standard Steel Works division of Baldwin-Lima-Hamilton Corp., Burnham, Pa.

Gordon F. Simons is now director of engineering and development for the Beryllium Corp., Reading, Pa. An employee of the company since 1933, Mr. Simons' last position was works manager.

William V. Wright, Jr., who received his Ph.D. from California Institute of Technology in June 1955, is at present program director, semiconductor materials, research and development department. of Pacific Semiconductors, Inc.

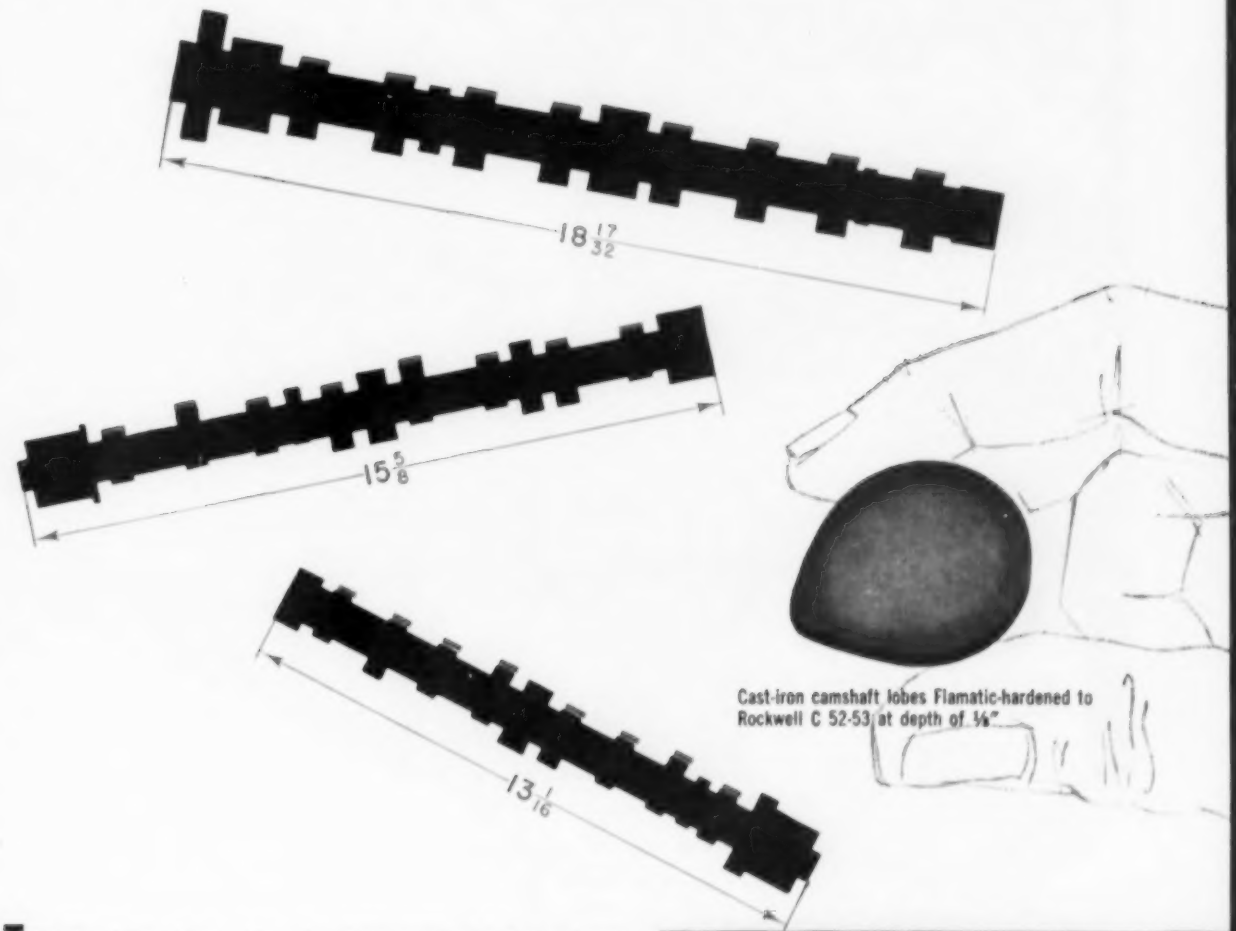
Paul Kloeris, Jr. is now materials and process engineer in the Santa Monica, Calif., division of Douglas Aircraft Co., Inc.

Kenneth M. Acton has been appointed assistant manager of the San Francisco sales branch of the Crucible Steel Co. of America. An employee of the company since 1941, Mr. Acton was a sales engineer at the San Francisco branch prior to his appointment.

E. S. Byron has rejoined the Westinghouse Electric Corp., Pittsburgh, as an engineer in the atomic power division. Mr. Byron spent 2½ years with the Sylvania Electric Products, Inc.

Quentin D. Davison has been promoted from purchasing agent to heat treat engineer in charge of the heat treat division at the Caterpillar Tractor Co., Joliet, Ill.

1 flamatic hardens 3 different camshafts



Cast-iron camshaft lobes Flamatic-hardened to Rockwell C 52-53 at depth of 1/8"

THE drawings above show the three camshafts that a large automotive manufacturer asked Flamatic to harden selectively on a single machine. The close-up at the right shows how Flamatic flame hardening solved the problem through simple, ingenious tooling. The machine achieves high production, yet set-up changes take less than 15 minutes. The operator positions the water-cooled shield, sets the selector-switch for the proper flame head, and adjusts the work-holding fixture. The cycle is then automatic except for loading.

This is another case out of hundreds showing how Flamatic selective hardening provides rapid heating and precise temperature control which results in high production and uniform performance over a wide range of parts. Write for Catalog No. M-1861, or send us part prints for analysis.

CINCINNATI **flamatic**

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.

Personals . . .

Roy L. Stewart, Jr. is now a sales engineer for the Stockham Valves and Fittings Co., Birmingham, Ala. Mr. Stewart covers the midwest territory for the company, working out of Chicago.

W. H. Neu has been named Pittsburgh district manager of the Leeds and Northrup Co., Philadelphia. Prior to this position, he was district manager of the Cincinnati office.

Howard H. Casey, formerly vice-president in charge of sales and engineering at the Midvale Co., Philadelphia, has been named general superintendent and manager of engineering for the New Midvale-Heppenstall Co., Philadelphia. Mr. Casey joined the Midvale Co. in 1952 as general manager of sales and prior to that time was with the Camden Forge Co., Camden, N. J.

Edward J. Rupert has joined Sundstrand Aviation, Denver division of Sundstrand Machine Tool Co., Rockford, Ill., as a chief metallurgist. Mr. Rupert was formerly director of research with Ipsenlab of Rockford, Inc.

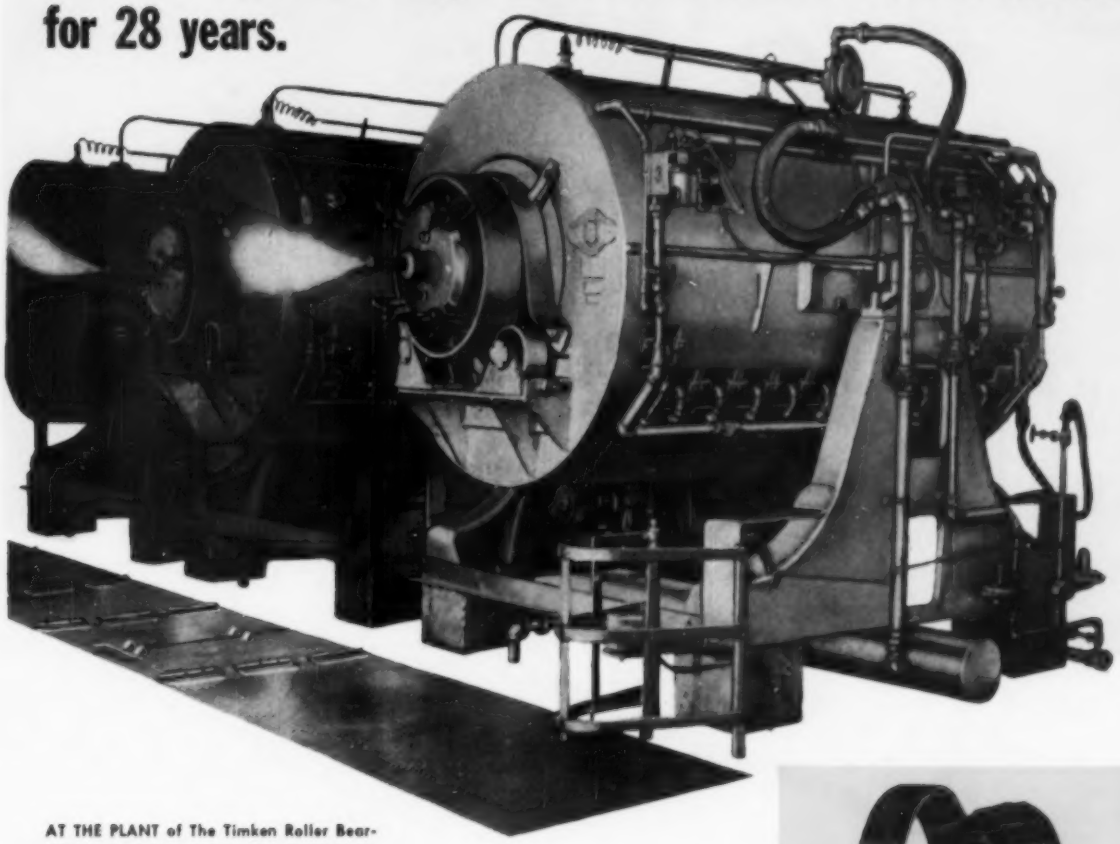
Stanley Weiss, recent recipient of a master's degree in metallurgy from Massachusetts Institute of Technology, has accepted a position with Alco Products, Inc., Schenectady, N.Y., as welding development engineer.

Bert R. Lanker has resigned as director of metallurgy of the Bingham-Herbrand Corp., Toledo, Ohio, to accept a position as fellow engineer with the atomic power division of Westinghouse Electric Corp., Pittsburgh.

John W. Gross, recently discharged from the U.S. Army, has resumed work with the Cleveland Graphite Bronze Co. as an assistant metallurgist. While serving in the Army, Mr. Gross was metallurgist in Army Ordnance at Frankford Arsenal, Philadelphia.

Walter E. Baker, Jr. has been named Pittsburgh sales manager for the Universal-Cyclops Steel Corp., Bridgeville, Pa. Mr. Baker has been associated with Universal-Cyclops as a sales representative in the Pittsburgh district since 1950.

AGF ROTARY RETORT CARBURIZERS have been used for heat treating TIMKEN ROLLER BEARINGS for 28 years.



AT THE PLANT of The Timken Roller Bearing Company in Canton, Ohio, more than 22 of these AGF Model No. 4 Rotary Retort Carburizers have been purchased over a period of years for carburizing rollers and races of roller bearings.

Each furnace is capable of receiving loads of 1000 to 1300 pounds depending upon the size and shape of the work. A cold charge is raised to carburizing temperature within 1½ to 2 hours from the time it is introduced and, of course, the carburizing cycle is maintained at temperatures up to 1700°, depending upon the case depth required.

Deep quenching tanks are located in front of the machines for end of cycle quenching.

MANY ADVANTAGES. Since 1925, TIMKEN has used AGF Rotary Carburizers. The ones shown were photographed after 9 or 10 years of operation. They are easy to maintain, convenient to use and have innumerable exclusive features.

Most important in carburizing rollers for roller bearings, the constant rotation of the work in the rotating retort leaves no possibility of variations in case. "Point of contact" carburizing case variations are entirely eliminated by this positive method. Three separate control zones assure uniform temperatures throughout the work space.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

TIMKEN Roller Bearing quality is known throughout the world and American Gas Furnace Co. is proud to have furnished some of the production equipment that helped establish and maintain that quality. AGF has furnished TIMKEN more than 100 heat treating and carburizing furnaces.

For 76 years AGF has PIONEERED in the invention, development and manufacture of industrial gas equipment for heat treating and other processes. Submit your problems to AGF metallurgists and engineers. WRITE for New Catalog. NOW.

AMERICAN GAS FURNACE CO.

1002 LAFAYETTE STREET — ELIZABETH 4, N. J.

Personals . . .

Herbert Wilhelm is now a metallurgist in production engineering at the Aro Equipment Corp., Bryan, Ohio.

Marion H. Cornell has accepted the position of technical trainee with the Aluminum Co. of America, Lafayette, Ind.

E. H. McIntyre has completed two years in England on an Athlone Fellowship, consisting of one year of industrial metallurgy at Birmingham University and one year with the United Steel Companies Ltd. He is now research assistant with Canadian Refractories, Ltd.

B. D. Rowland is plant metallurgist at the Joplin division of Vickers, Inc. Previously Mr. Rowland was metallurgical engineer in the research department of the United Gas Corp., Shreveport, La.

Charles H. Pitt is at present taking graduate work at the school of metallurgy of the University of Utah.

Albert S. Melilli, a 1955 graduate of the Colorado School of Mines, has been transferred to the Metals and Ceramics Dept., Knolls Research Laboratory, General Electric Co., Schenectady, N.Y. while on the chemet training program.

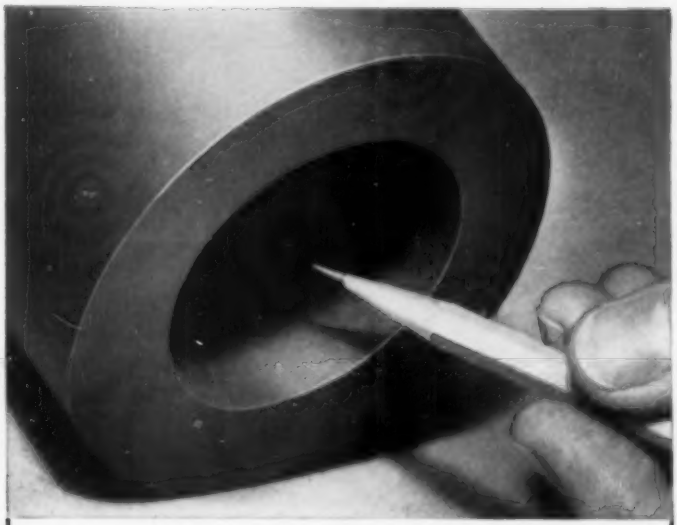
Richard H. Weichsel has formed a new concern to sell and manufacture precision sleeve bearings of sintered metal. Mr. Weichsel will also act as a bearing consultant.

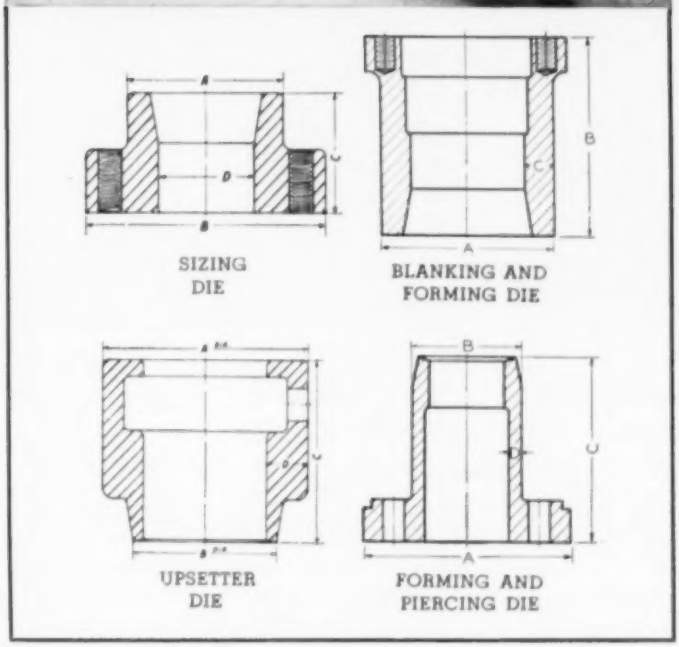
B. S. Subramanya, a graduate of the Indian Institute of Science, Bangalore, India, has joined the department of metallurgy of the University of Illinois as a part-time research assistant. Mr. Subramanya is studying for his master's degree.

Sidney L. Simon is now director of the applied research department in the advanced development division, Avco Mfg. Corp., Stratford, Conn.

K. J. Irwin, a recent recipient of a master's degree in welding engineering from Ohio State University, is now engaged in developmental work in chemical industrial equipment at E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.

SPEED PRODUCTION, CUT WASTE WHEN MAKING RING-SHAPED TOOL STEEL PARTS





New Graph-Mo® Hollow-Bar eliminates drilling, machines 30% faster

IF you make ring-shaped tool steel parts, you'll find that you can speed production, cut waste, and save steel by using Graph-Mo® Hollow-Bar. That's because Graph-Mo Hollow-Bar comes with the hole already in it. There's no drilling. You start with finish boring.

And with Graph-Mo Hollow-Bar you get the combination of proved advantages that have made Graph-Mo one of the most popular tool steels: excellent machinability, exceptional wearability, unsurpassed stability.

Actual tests prove that Graph-Mo machines 30% faster than other tool steels. That's because Graph-Mo has free graphite in its structure. And this free graphite gives Graph-Mo less tendency to pick up, scuff, and gall.

Graph-Mo's amazing wear resistance stems from a combination of graphite and diamond-hard carbides. Reports from users indicate that Graph-Mo outwears other tool steels on an average of three to one.

Graph-Mo also is the most stable tool steel ever made. A master plug gage made from this steel showed less than ten millionths of an inch dimensional change after 12 years in use. And Graph-Mo responds uniformly to heat treatment, too.

Makers of ring-shaped tool steel parts may obtain Graph-Mo Hollow-Bar in sizes from 4 to 16 inches O.D. with various wall thicknesses.

To learn more about Graph-Mo Hollow-Bar, and its application to your problems, write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Personals . . .

C. E. Meissner has retired from his position as full-time Washington representative for the Budd Co., Philadelphia, but will still be retained as a part-time consultant on governmental relations for the company. Mr. Meissner will also assist other industrial interests in developing business with the government and armed forces.

Murray C. Udy, formerly assistant division chief, Battelle Memorial Institute, Columbus, Ohio, is now director of research at Strategic-Udy Metallurgical and Chemical Processes Co., a subsidiary of Strategic Materials Corp., Niagara Falls, N. Y. and Niagara Falls, Ont.

Joseph S. Mathias has joined the research center of Jones and Laughlin Steel Corp., Pittsburgh, as a senior research engineer. Prior to this position, Mr. Mathias was chief chemist and metallurgist at the Superior Metal Co., Bethlehem, Pa.

John W. Kane has been transferred from the Houston, Tex., district of the U.S. Steel Supply Division of U.S. Steel Corp., to the Cleveland district.

Robert E. Valk has been appointed administrative assistant to the vice-president in charge of production of the Electric Auto-Lite Co., Toledo, Ohio. Prior to his recent appointment, Mr. Valk was associated with the National Supply Co., Toledo.

Stephen L. Ingersoll has been elected president and general manager of the Ingersoll Steel Div., New Castle, Ind., a subsidiary of the Borg-Warner Corp., Chicago. Joining Ingersoll in 1920, Mr. Ingersoll was elected vice-president in 1930 and in 1954 was elected executive vice-president.

David E. Deutsch, formerly a major in the U.S. Air Force, has joined the technical staff of the Fansteel Metallurgical Corp., North Chicago, Ill., as senior metallurgist. While in the Air Force, Mr. Deutsch was a staff metallurgist in the nuclear energy laboratories at Los Alamos, N. M., and more recently was in charge of materials research for the Air Force aircraft nuclear propulsion program.

"Quality in our heat treating calls for GULF SUPER-QUENCH in our tanks"

says Mr. Lloyd Mattson, owner, Quality Steel Treating Co. of Anderson, Indiana.

"QUALITY is not just a name with us. We carry it through every operation in the heat treatment of tools, dies, and precision parts for aircraft and automotive equipment," says Mr. Mattson. "And much of the credit for our quality heat treating belongs to Gulf Super-Quench which delivers deep, uniform hardness without cracking or distortion."

The superior quenching power of Gulf Super-Quench assures deeper, more uniform hardening even on steels of variable hardenability and on parts with variable sections or odd shapes. This results in fewer rejects and a substantial saving in money.

Another important reason for Gulf Super-Quench's high rank among heat treating concerns is its ability to retain its fast dual quenching power indefinitely with only normal make-up. There is no need for additive replenishment.

Perhaps a Gulf Sales Engineer can help you find opportunities to use Gulf Super-Quench profitably in your shop. Consult the telephone directory for the number of your local Gulf office.

THE FINEST PETROLEUM PRODUCTS FOR ALL YOUR NEEDS

GULF OIL CORPORATION
1822 Gulf Building

GULF

GULF REFINING COMPANY
Pittsburgh 30, Pa.

Personals . . .

Eric Gregory, formerly associated with the Manganese Bronze and Brass Co., Ltd., Ipswich, England, is now a research associate at the Sintercast Corp. of America, Yonkers, N.Y.

George P. Gradolf, formerly chairman of the board and treasurer of the Cincinnati Bickford Tool Co., has retired.

Robert A. Huber, having completed his training at the University of Notre Dame, is now assistant metallurgist at the Supreme Metals Treating Co., Milwaukee, Wis.

Raymond Fostini has left the atomic power division of Westinghouse Electric Corp., Pittsburgh, to accept a position as metallurgist at the Foster Wheeler Corp., New York.

Frank V. Nolfi, formerly associated with the Copperweld Steel Co., Glassport, Pa., for 15 years, is now assistant superintendent of cold finishing at the Northeastern Steel Corp., Bridgeport, Conn.

Marvin Happ is now research assistant in the department of metallurgy of Massachusetts Institute of Technology. Mr. Happ was formerly employed by the General Electric Co.

George H. Hatfield has been transferred to Dallas, Tex., to open a new branch office for Esch and Associates, Inc., Houston, Tex.

Donald E. Baxter, after being discharged from the U.S. Army, returned to Wyman-Gordon Co., Worcester, Mass, as a forge shop metallurgist.

Stuart C. Lawson has been selected by WW Alloys, Inc., division of Fansteel Metallurgical Corp., Detroit., as sales representative for the Wisconsin and Rockford-Freeport area in Illinois. Mr. Lawson resigned as general sales manager of Ampco Metal, Inc., Milwaukee, Wis. in 1955 and formed his own business as a manufacturers' representative.

E. M. Schempp was recently named manufacturing manager of the steel division of the Henry Disston Div., H. K. Porter Co., Inc., Philadelphia.

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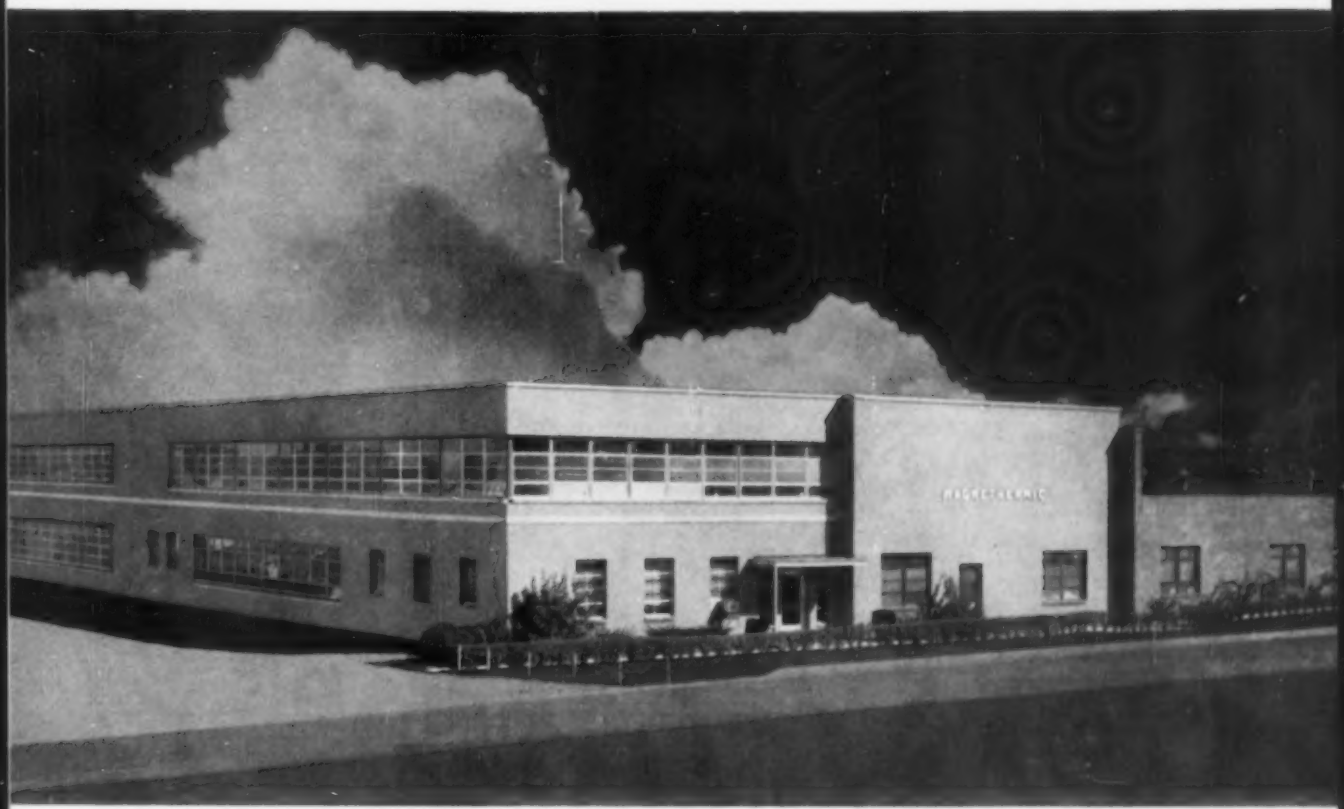

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Personals . . .

A. D. Shankman, formerly U.S. Air Force materials and processes representative at the Ford Aircraft Engine Division, Chicago, has accepted a position as metallurgist in the materials and processes engineering department of the Douglas Aircraft Co., El Segundo, Calif.

Anthony R. Ozanik has left the post of head, engineering and development branch, Naval Ordnance Test Station, China Lake, Calif. to accept the position of plant manager, Sandshell Corp., Santa Clara, Calif.

Robert T. Joy, formerly manager of Macwain Industries, Inc., Cleveland, is now a project engineer in fuel systems development at the Inglewood, Calif., laboratory of Thompson Products, Inc.

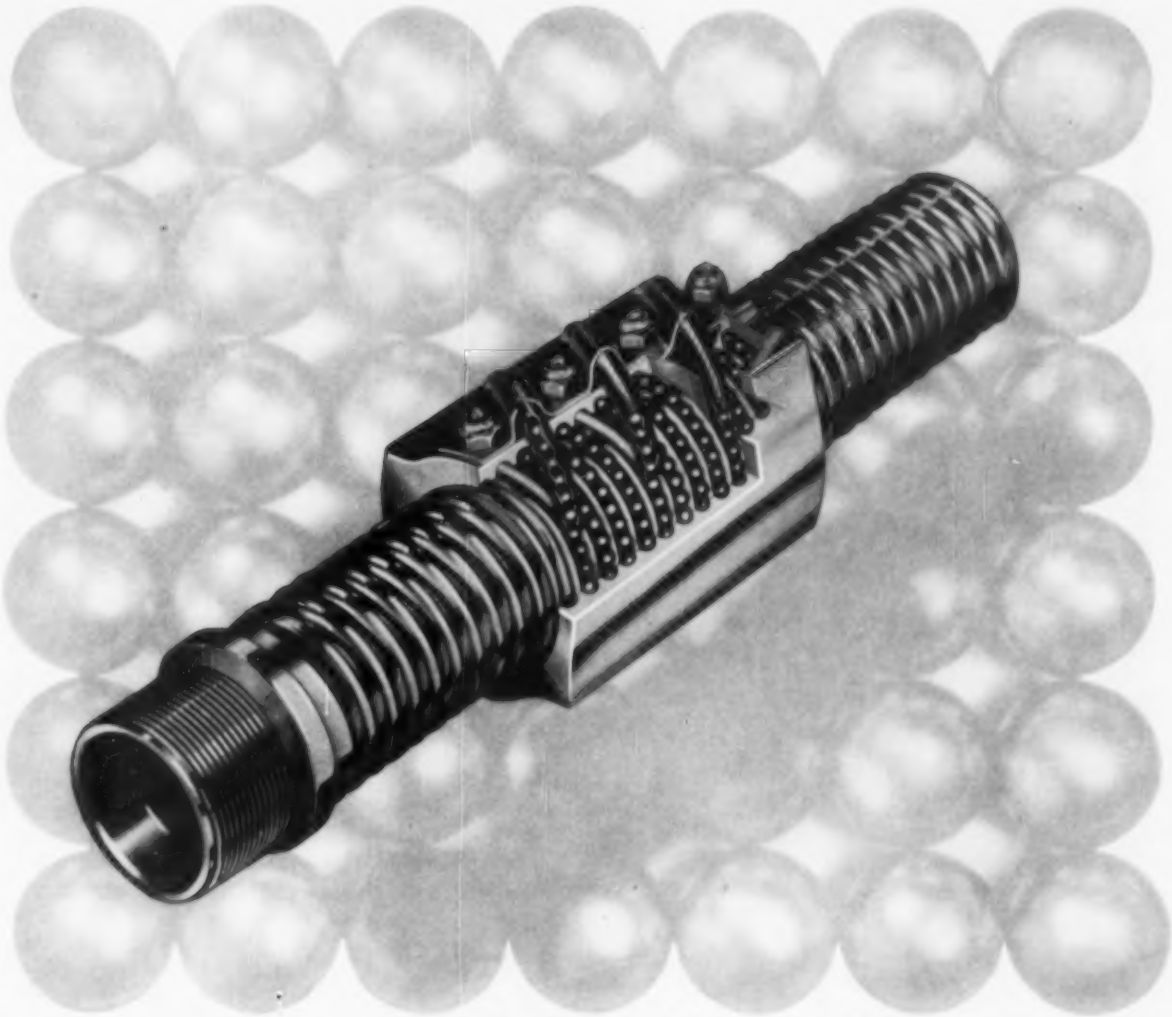
C. Clement English has been appointed manager of high-temperature metal sales for the Universal-Cyclops Steel Corp., Bridgeville, Pa. Prior to his new appointment, Mr. English was district sales manager of the Dayton-Cincinnati territory for the company.

Roger F. Waindle has been appointed chief, castings branch, Iron and Steel Div., Business and Defense Services Administration, U. S. Department of Commerce. Mr. Waindle is on loan from his positions as vice-president of the Misco Corp., staff consultant of Consolidated Foundries and Mfg. Co., and president of WaiMet Engineering Co., Boston, under a rotation system whereby outstanding businessmen volunteer their services for periods of six months or longer without government compensation.

John B. Fenstermacher is now associated with Thomas S. Hutton and Son, San Francisco. Mr. Fenstermacher has been active in sales of high-alloy and special steels for 12 years.

P. W. Flynn is now disbursing officer on the U.S.S. Winston and will be stationed on this ship for one year.

R. P. Goulet is now working in the sales technical laboratory and in the chlorine products group of the Elchem Div., E. I. du Pont de Nemours and Co., Inc., Niagara Falls, N.Y.



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Personals . . .

Hans W. Bluethe was recently promoted to advertising manager, industrial division, of the Surface Combustion Corp., Toledo, Ohio. Mr. Bluethe joined the corporation's industrial advertising department in May 1955 and prior to that time was associated with Lindberg Engineering Co. and Wheelco Instruments Co. in Chicago.

Norman Calkins, formerly assistant manager of toolsteel sales at the Universal-Cyclops Steel Corp., Bridgeville, Pa., has been appointed manager of toolsteel sales. Before joining Universal-Cyclops, Mr. Calkins was a member of the sales staff of the Carpenter Steel Co. for nine years.

Robert Potter, formerly an executive vice-president of the E. W. Bliss Co., Canton, Ohio, has been elected president and chief administrative officer of the company. Mr. Potter was also elected a director and a member of the executive committee of E. W. Bliss.

Tien-Shih Liu will head a government research project on titanium hydride formation at Horizons Inc., Cleveland. The project, awarded to Horizons by the Office of Naval Research, Washington, D.C., will be under the direction of **Morris Steinberg**, head of the department of metallurgy at Horizons.

Raymond A. Quadt was recently awarded the Meritorious Public Service Citation in recognition of development of new aluminum alloys and their application to cold forged rocket motor tubes, mechanical time fuse bodies, and proximity fuses for the Navy. Currently with the recognition, Mr. Quadt was appointed vice-president of the Hunter Douglas Aluminum Corp., Riverside, Calif. Mr. Quadt had previously been employed as assistant vice-president.

Edward N. Case has been elected president of the newly formed Salt Bath Institute at a recent meeting in Cleveland. Mr. Case is sales manager of the Ajax Electric Co., Philadelphia. Prior to that position, he was manager of the metals chemicals section of the American Cyanamid Co., New York, for 12 years.

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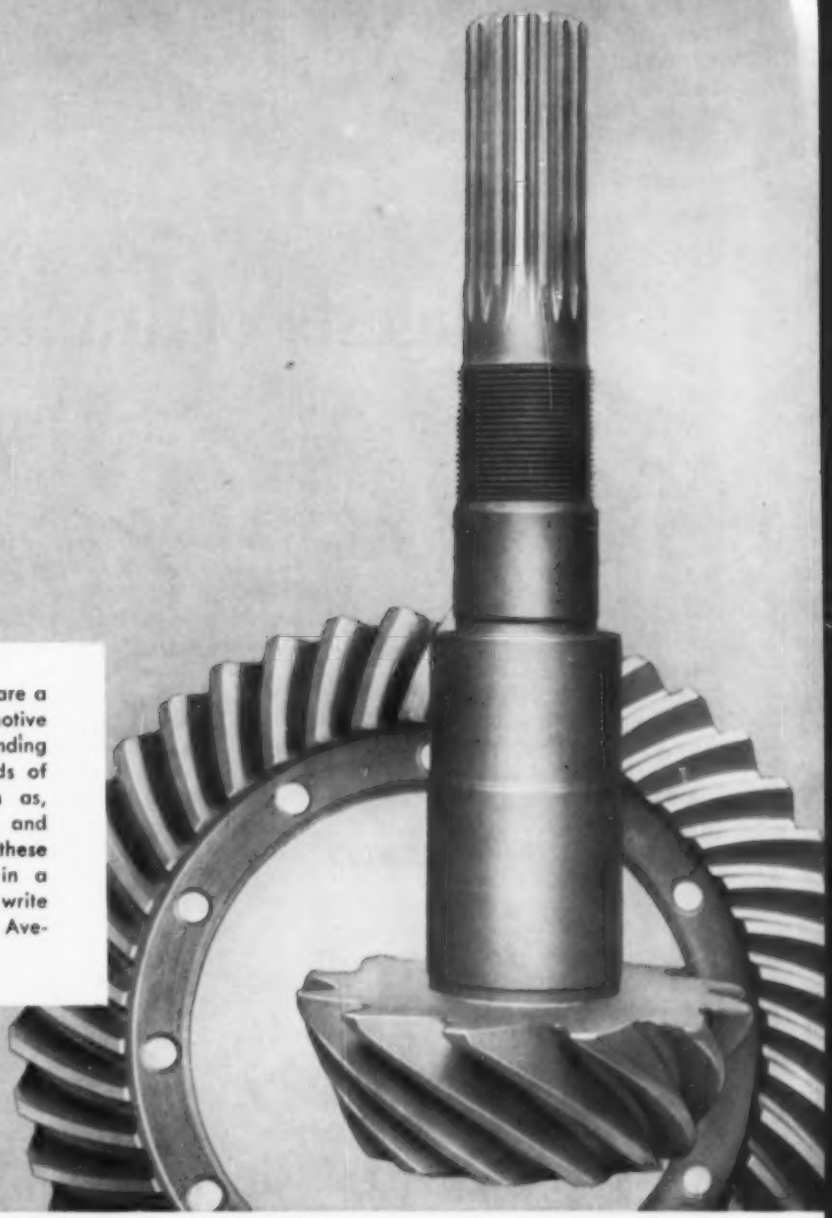

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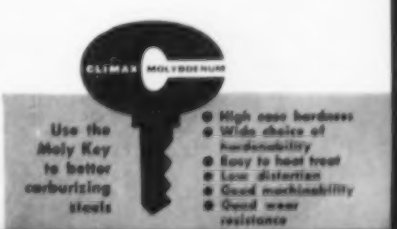


Digests of Important Articles

Weld Cracking Test

Digest of "A Simple Cracking Test for Use With Argon-Arc Welding", by P. T. Houldcroft, *British Welding Journal*, Vol. 2, October 1955, p. 471 to 475.

MANY forms of tests have been devised to determine susceptibility to weld-metal cracking during fabrication. One of the great difficulties of such laboratory testing is the interpretation of results in terms of practical significance.

In the welding of certain aluminum alloys, particularly those which are crack sensitive, cracking is likely to occur if a weld is started from the edge of the sheet. This tendency to cracking is somewhat dependent upon sheet dimensions, particularly width.

Practical experience in welding the crack-sensitive alloys has shown that, with a silicon alloy filler metal, cracking tendency decreases as the silicon content of the weld metal is increased.

With these points in mind, experiments were made using a butt joint specimen clamped tightly in a restraining jig arranged so that the distance between the clamping bars could be varied to alter the restraining effect on the test weld from specimen to specimen. However, this form of test is not sensitive enough for selection either of welding materials, technique or base metals. Attention was therefore given to the development of a simpler and more selective test.

The aim was to initiate a crack in the weld bead by starting the weld at the edge of the sheet and then to stop propagation of the crack by a change in the shape of the test piece. During experiments with a crack-sensitive Al-Mg-Si alloy it was found that a crack would propagate through the length of a weld bead made without filler metal along the centerline of a 1¾-in. strip of 16-gage sheet. A crack-arrest mechanism was set up by tapering the strip to gradually decrease the width as the welding progressed. However, it was found that the width of the weld bead increased as the strip width decreased because of the heat build-up.

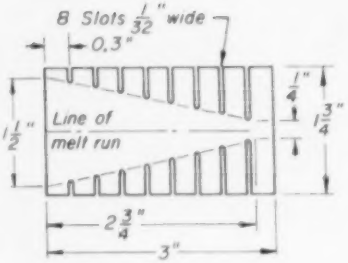
To prevent this widening of the weld bead the strip width was maintained essentially constant and a series of slots of increasing length was cut in from both sides of the strip so as to obtain a decreasing stress level of restraint as the weld bead progressed. The specimen is shown in the drawing alongside.

With this specimen the distance the crack extends along the weld bead is a measure of the crack sensitivity of the base metal when no filler metal is added. By adding filler metal the test can be used to evaluate the cracking tendency of any combination of filler and base metals.

For the 16-gage material a current of about 60 amp. is used with the argon arc. For ¼-in. sheet the specimen dimensions are increased by 50% and a current of 120 to 140 amp. is used. For effective testing complete penetration through the sheet is essential.

In making the test, the specimen is laid on a carbon block approximately ⅜ in. thick, which in turn is placed on a water-cooled copper block. The carbon block is ideal for a backing because, although it conducts heat poorly, it is capable of conducting the welding current to the test piece. When a series of tests is to be made, several blocks are used in rotation so that each block is at room temperature when used.

The severity of the test depends upon the size and shape of the test specimen. An increase in both welding current and speed of travel of the arc increases the thermal gradients and hence the severity of the test. The dimensions of the specimen and the welding conditions prescribed were selected to give a severity comparable with that of the normal range of commercial aluminum alloys.



Test Piece for Edge-Start Crack Tests in 16-Gage Sheet

Generally, the cracks are easily visible to the naked eye but examination with a low-power binocular microscope can help to detect intermittent or multiple cracks.

WILLIAM L. WARNER

Wear of Machine Tool Components

Digest of "The Wear of Cast-Iron Machine Tool Slides, Shears and Guideways", by H. T. Angus, D. Marles, and M. H. Hillman; British Cast Iron Research Assoc. *Journal of Research and Development*, Vol. 6, December 1955, p. 72-135.

THE FRAMEWORK and slides of machine tools are made of cast iron because of its availability and low cost, and in most instances its resistance to wear has been satisfactory. Abnormally rapid wear or serious scratching, scoring, scuffing, galling or tearing on rubbing surfaces between moving parts of cast iron machine tools has occasionally occurred even though the loads and speeds were very low. In this report a study of 30 used machine tools is

Wear Resistance . . .

presented, which was undertaken to determine the reasons for unusually worn or unusually resistant surfaces.

Four different types of deterioration of machine tool slides are defined and different kinds of wear are described. Sliding wear does not occur under conditions of full lubrication, but only when the oil film is broken or locally interrupted at high spots. Abrasive wear is caused by dirt between the sliding surfaces. Resistance to such wear is better when these surfaces are harder. Fretting corrosion, in which the removed metal particles are immediately oxidized, occurs only with small vibrations and where the oil is squeezed out locally. This condition may occur in shipment or from floor vibrations rather than in use of a machine tool.

There is no relation between hardness and resistance to steady sliding wear in machine tools. Chilling or hardening of the sliding surface was not advantageous; when the two surfaces differed in hardness, the harder one wore faster. Possibly this was due to abrasive dirt becoming embedded in the softer surface and scratching the harder. Wear resistance was increased by high carbon and phosphorus, low silicon and medium-sized graphite. The importance of high phosphorus for sliding wear resistance has been confirmed by others.

In rotating wear of cast iron against steel at heavy pressure, high phosphorus or carbon in the iron has little effect on galling or seizing, the surface of the steel being most important. Continuous operation, as in most wear tests, is more favorable to wear resistance than intermittent motion or use. Fretting corrosion occurs very rapidly with small vibrations and very light loads.

Most lubricants are reported to be ineffective against fretting corrosion because they are too easily removed locally and do not prevent oxidation. A hard wear resisting sliding surface is formed by proper running-in of a new bearing to rub off projections. For that process a lubricant that forms a soap with the metal surface and oxygen should be used. Fatty acids make superior lubricants because they produce metallic soaps of comparatively high melting point which is important for polishing agents. Graphite is a good lubricant only in older bearings since it does not cover a freshly ground surface well. Phosphate coatings are useful for new bearings because they are porous enough to hold lubricant. This property is also useful where fretting corrosion may occur.

No wear tests were carried out in connection with the present work, the only experimental work being the grading of the worn surfaces on the 30 tools studied and photographed, and the determination of the chemical composition, hardness, and microstructures of each worn iron part. These data are presented in an extensive table and by numerous excellent illustrations. The length of service of the tools ranged from 7 to 35 years.

The phosphorus contents received special attenion. The slides that were in good condition ranged from about 0.4 to 1.2% in phosphorus content with an average of 0.82% Those graded fair ranged from 0.28 to 1.4% phosphorus, the average being 0.96%. Those graded bad had a similar range, with 0.66% average, while the very bad slides were all below 0.4% phosphorus with 0.28% average. Thus the phosphorus con-

tent is not the only controlling factor in wear resistance although it is important. Most of the low-phosphorus slides that were in better condition had fully pearlitic structures; most of the high-phosphorus slides in poor condition contained considerable ferrite.

The five common types of cast iron structures were all found among these samples. Fine undercooled graphite is generally unfavorable for wear resistance although sometimes good resistance has been reported for that structure. Chilling may promote such a structure either at or just below the surface and lead to lower resistance to wear. Under certain conditions chilling may be justified. The structures most favorable to good wear resistance are medium to coarse flake graphite either in pearlite without ferrite, or with a little ferrite and high phosphorus. Phosphorus above 0.8% shows some evidence of being more important for wear resistance than a fully pearlitic structure. Too much ferrite may permit the embedding of abrasive dirt which would cause rapid wear.

No new evidence or conclusions regarding wear appear to have been developed by this extensive collection of data. The discussion is of interest because it indicates the complexity of the subject.

G. F. COMSTOCK

Creep of Vanadium-Bearing Steels

Digest of "The Effect of Vanadium Upon the Creep Strength of Low-Alloyed Steels for Tubes", by O. L. Bihet, Joint Metallurgical Societies Technical Session in Liège, Belgium, June 13, 1955, 13 p.

VANADIUM in steels containing 0.72 to 2.58% Cr and 0.26 to 1.3% Mo makes them susceptible to precipitation hardening and increases creep strength. The best creep strength is attained by tempering for a longer time than is required for maximum hardening. If the tempering temperature is too high, maximum creep strength will develop too rapidly and long-time creep strength will be impaired. If too low, no hardening occurs. With a 0.5% Mo steel, tempering 10 hr. at 1200° F. increased the time for 0.1% creep at 1020° F. and 13,440 psi. from 800 to 1400 hr.

In 1% Cr steels, the composition range found to be most favorable for high-temperature strength is 0.09 to 0.14% carbon, 0.9 to 1.1% chromium, 0.45 to 0.55% molybdenum, 0.4 to 0.5% vanadium and 0.35 to 0.45% tungsten. When it is normalized at 1790° F. and tempered 5 hr. at 1310° F. the 100,000-hr. rupture strength at 1070° F. is 15,600 to 17,000 psi., and the stress for 1% creep in 100,000 hr. about 10,670 psi. Its stress-rupture curve is slightly higher than the A. S. T. M. curve for 1% Mo, 0.2% V steel, normalized at 1920° F. and tempered 12 hr. at 1300° F. Normalizing at 1650° F. gave lower long-time strength; the beneficial effects of vanadium depend on high-temperature heat treatment as well as tempering.

Chromium-molybdenum-vanadium steel for bolts, heat treated to a yield strength of about 142,000 psi.,

Vanadium Steels . . .

occasionally becomes brittle after long exposure under stress at high temperature. A short-time creep test may not show this embrittlement but it can be detected by a comparison of 10,000-hr. stress-rupture curves of notched and unnotched specimens. If these curves cross, brittle rupture may be expected after service at the same temperature for a longer period of time than that at which the crossing occurred. An instance is quoted of the crossing of such curves after 1000 hr. at 930° F. (the stress is not stated) with a steel composition of 0.17% C, 0.92% Cr and 0.56% Mo, while with a steel containing 0.18% C, 1.5% Cr and 0.34% V, the notched and unnotched curves did not cross until after 10,000 hr. The vanadium-bearing steel was less sensitive to notches and also showed greater elongation at rupture.

In the same series of tests, the most notch-sensitive steel by this criterion was one containing 0.11% C, 1.53% Ni, 0.72% Cr and 0.88% Mo. A steel containing 0.22% C, 1.62% Cr, 0.43% Mo and 0.39% V was also somewhat notch-sensitive. Similar steels containing 0.15 or 1.03% V showed no notch sensitivity. It is concluded from these results that vanadium alone does not cause embrittlement or notch sensitivity.

Brittleness occurs in hardened steels containing Cr, Mo and V only when they are tempered so low (1220° F.) that the yield strength is above 120,000 psi. With yield strength about 107,000 psi., such a steel has a 100,000-hr. rupture strength at 930° F. of 20,600 psi. and 17.7% elongation when rupture occurs under 28,400 psi. Without vanadium, equivalent values are 14,200 psi. rupture strength and 24.6% elongation. The impact strength is over twice as high for the vanadium steel.

An increase in tensile strength at room temperature does not necessarily give a higher 100,000-hr. rupture stress at high temperature. Brittleness at high temperature in Cr-Mo-V steels is usually caused by the heat treatment rather than by the vanadium. In Cr-Mo steels for use at 930 to 1050° F., vanadium contents of 0.15 to 0.25% are beneficial.

G. F. Comstock.

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Properties of a French Aluminum Alloy

Digest of "Casting Alloy Al-Zn-Mg, A-Z5G", by H. Roinet; Joint Metallurgical Societies Meeting in France, June 1955.

THE ALUMINUM casting alloys containing zinc and magnesium have been used in France for about 15 years. They are changed very little by remelting and have good mechanical properties and machinability after aging at room temperature or air cooling from 360° F. The French alloy A-Z5G is the same as Frontier 40-E, namely, 5% Zn, 0.5% Mg, 0.2% Ti, and 0.3% Cr. This alloy has a fine structure with good strength, ductility, impact and corrosion resistance. If either zinc or magnesium is increased, the strength may be higher but the ductility is too low; 5.5% zinc is the usual upper limit, and if magnesium increases to 1.5%, the alloy is brittle. For best corrosion resistance, chromium content should be 0.2 to 0.6% and copper 0.15 to 0.2%. Silicon should not be over 0.3%, but iron may be as high as 0.8 to 1%.

With natural aging the tensile strength is 31,300 to 35,600 psi., the yield strength 18,500 to 22,800 psi., and the elongation 5 to 9%. After aging 10 hr. at 360° F. the properties are about the same except that the tensile strength is about 10% lower. The tensile properties of test bars and actual castings are more nearly alike in this alloy than in other common aluminum casting alloys. The fatigue limit at room temperature is 9,250 to 10,700 psi.

The castability and hot shortness are about the same as for other aluminum alloys but there is a greater tendency toward piping. In melting, over-heating should be avoided; chromium and titanium may be lost. The pouring temperature for test bars should be 1330 to 1380° F. and for castings 1330 to 1420° F. Remelting of scrap gives no trouble, and the usual molding practices can be used in sand or chills. The riser ratio need be no more than 1 to 1.8 or 2.

During aging at room temperature or 360° F., a contraction of 0.008% may occur. The alloy is readily machined, welded, polished, anodized and brazed. Resistance to atmospheric corrosion is good.

G. F. COMSTOCK

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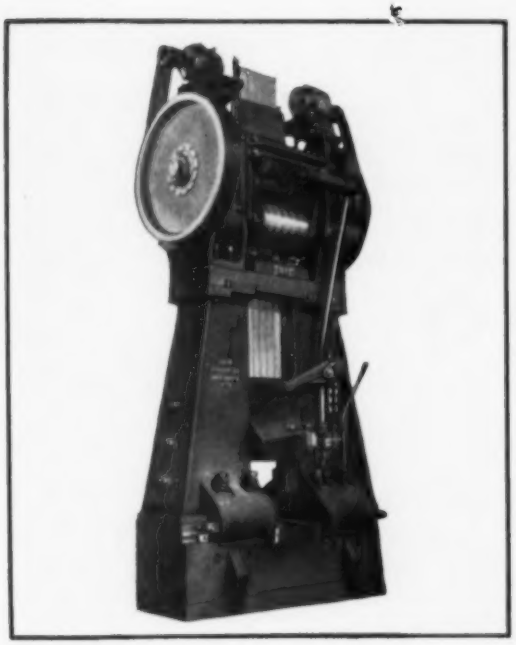

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Stress-Corrosion Cracking of Stainless

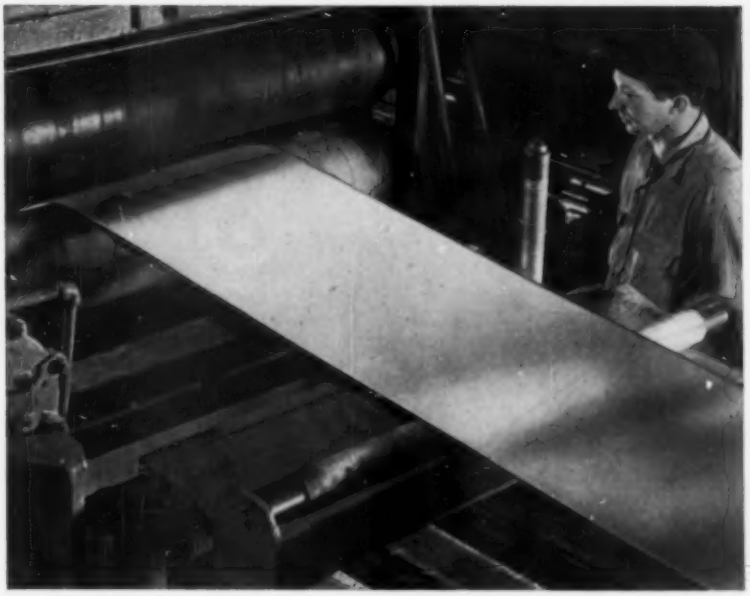
Digest of "Mechanism of the Stress-Corrosion Cracking of Austenitic Stainless Steels in Hot Magnesium Chloride Solutions", by T. P. Hoar and J. G. Hines; *Journal* of the Iron and Steel Institute, Vol. 182, February, 1956, p. 124-143.

INTERGRANULAR cracking in austenitic stainless steel is associated with carbide precipitation but transgranular cracking is caused by stress. The corrosive attack of many chemicals, such as hot solutions of inorganic chlorides, impure steam and ethyl chloride, exaggerates the effect of stress in producing the cracks. The higher the stress, the more rapid is the failure. The corrosion connected with these failures depends on the breakdown of protective oxide films, the stress rendering the alloy less noble.

Most stress-corrosion cracking tests have been made on bent sheet specimens, in which elastic and plastic stresses are confused so that it is very difficult to stress different specimens uniformly. For this work wire specimens loaded in tension were used. In these tests small cracks in the specimen increased the stress so that failure was hastened whereas with bent specimens small cracks relieve the stress and might escape detection for a long time. A hot concentrated $MgCl_2$ solution was used as the corrodent. The test specimens were 0.02-in. diameter wires of ten different stainless steels containing 0.07 to 0.11% C, 17 to 19.5% Cr, 7.8 to 10% Ni, 0.3% to 1% Si, and up to 1.6% Mn, 0.7% Ti, 3% Mo, 1% Cb, 0.4% Cu, or 0.06% N.

The wire passed through a heated vertical pyrex tube containing the corrodent. The wire above the solution was protected by a small tube containing nitrogen. The specimens were loaded by a lever that opened a time switch when failure occurred. A pH meter was used to measure the electrical potential between the specimen and a connected Ag-AgCl reference cell. The potential readings were closely reproducible between experiments.

Preliminary experiments showed that the standard deviation of the fracture time for duplicate experiments with one material and one set



TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.

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Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

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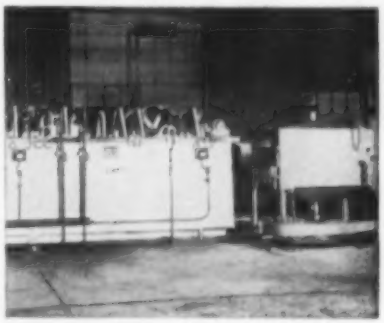
You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.

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Stress-Corrosion . . .

of conditions was about 20% of the average. Most of the alloys failed from one major crack in each specimen, with numerous minor cracks near the point of failure. Two of the molybdenum-bearing steels and one titanium-bearing steel had several large cracks along the exposed specimen length.

In measuring the corrosion potentials of specimens exposed to stress-corrosion, five specimens connected together were tested simultaneously. Unstressed specimens show an initial drop in potential as the solution penetrates into breaks of the oxide film, then an increase as the film is repaired, and later another drop until solution of metal in the pores is established and the corrosion rate becomes steady.

Stressed specimens have similar potential-time curves except that they are lower and show a rapid drop in potential a few minutes before fracture with an equally rapid recovery. This rapid potential fall occurs earlier with higher stress. The mechanical properties are affected very little during these stress-corrosion tests until the rapid fall of potential occurs; then the elongation is decreased more than the strength. Extension measurements indicate that practically no cracking occurs until the last few minutes before fracture after an induction period of corrosion. This was confirmed by tests of specimens corroded first without stress and stressed later. The induction period is generally about 20 to 200 min. in these tests at about 300° F. The specimen does not fail until the potential reaches its maximum.

At higher stresses the times to fracture of all the steels were similar; at low stresses, most of the alloys required longer times to fracture but two of the molybdenum-bearing steels and one titanium-bearing steel fractured nearly as quickly at 500 psi. as at 50,000. The effect of stress increase is greater in all the steels at low stresses than at high. The change of corrosion potential with time at different stresses indicates that an increase in stress has a minor effect on the preliminary corrosion process and only a slight effect on the period of crack propagation.

Some specimens were pickled to remove the natural oxide film and tested after different types of surface films were produced on them. A thicker, less porous film gives a longer induction period and a slightly longer period of final rapid potential fall before cracking. The kind of initial oxide film has little influence on long-term corrosion, or on fracture times at low stresses.

Small additions of acid (0.02% hydrochloric acid) to the magnesium chloride solution cause rapid film breakdown and crack propagation with an induction period shortened to a few seconds and early failure.

Stress-corrosion cracking does not start from deep pits but from spots where bare metal is exposed to the electrolyte by the corrosion reactions so that anodic solution is rapid. At such areas mechanical deformation is facilitated and a crack pit may start. Cathodically produced hydrogen may also weaken the surface and assist cracking. Crack pits seem to

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Stress-Corrosion . . .

require activation by a stress period even after damage from unstressed corrosion. They were propagated in these tests at a rate between about 0.5 and 3 mm. per hr.

After cracking has started it can be stopped by removing the load or by applying a small cathodic current. The theory of crack propagation by a joint mechanical-electrochemical mechanism, rather than by a mechanism of alternate strain and chemical attack, is favored by these authors. Calculations of the anodic current required agree with the observed lowering of potential during the crack-propagation period. The extension during crack propagation is discontinuous, possibly due to variations in yield strength between grains.

Changes in composition or in heat treatment or a reduction of internal or applied stress are probably of little value in eliminating or delaying stress-corrosion cracking of stainless steel. Cathodic protection, however, should reduce the corrosion damage during the induction period sufficiently to avoid any failures due to cracking of the type discussed in this paper.

G. F. COMSTOCK

Measuring Foundry Efficiency

Digest of "Application of Activity Sampling Technique in Ironfoundries", by A. A. Timmins; British Cast Iron Research Assoc. *Journal of Research and Development*, Vol. 6, December 1955, p. 137-140.

ACTIVITY sampling is also known as "snap readings" and consists of recording a series of observations at a number of instants over a given period of time as to whether or not a certain machine was running or a certain activity occurring, at each of the instants. When the readings are summarized, the percentage recording action gives a measure of efficiency and the percentage recording inaction indicates time lost. Multiple activities of a group can be examined simultaneously in this way. A stop watch is not needed and attention is focussed on movements and operations rather than on individual operations. *(Cont. on p. 160)*

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Efficiency Study . . .

In one foundry the pouring operations, apparently out of balance with the molding, were studied. Two 500-lb. ladles on an overhead monorail were used, each with one operator, to collect metal from the furnaces. One ladle served another operator with a shank ladle for pouring molds on a conveyer and the other ladle served two different operators pouring at a second conveyer. The activities of the five men were studied with 3290 snap readings in two days. It was found that the casters lost an excessive amount of time waiting for full ladles to come from the furnace. Some time was also lost in raising the large ladles high enough to fill the shank ladles and because the two operators pouring on the one conveyer interfered slightly with each other. The recommendations included a heated metal receiver at the furnace so the large ladles could be filled faster, and arrangement of the ladle heights and monorail tracks to facilitate the pouring.

At the second foundry all the operations of molding, pouring and shaking out appeared to be out of balance. Snap readings were taken on all these operations for two days, during a total of 8½ hr. It was shown that the molding unit was busy 92% of the time, the mold assembly operators 88%, those removing core arbors 62% and shakeout operators 75%. With only one ladle in operation two men spent 18% of their time pouring, 22% in transporting the ladle and 54% in refilling it. Installing a second ladle resulted in each ladle having to wait while the other was filled, so the total pouring time was increased only 15%. The molding operations were considered reasonably efficient. A heated metal receiver at the furnace was advocated to save time in filling the ladle, and a larger ladle was suggested so that more molds could be poured per trip.

At the third foundry operations were too complex for a complete study by the limited staff available and the incomplete observations are not reported. In the other two foundries the value of activity sampling is considered to have been demonstrated for studying the utilization of plant and labor.

G. F. Comstock

Lesson in Low Heat-Hour Cost at "YANKEE" TOOLS

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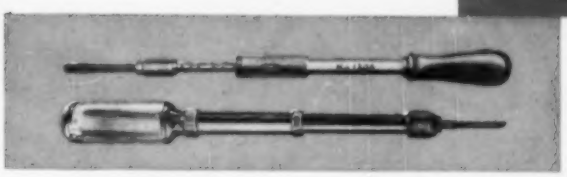

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Peterson considers this performance so excellent that Nichrome castings are used throughout the "Yankee" heat treating department in the form of pots for cyanide and lead baths, where their performance is also outstanding. That's why "Yankee" Tools has been a Driver-Harris customer for over 27 years.

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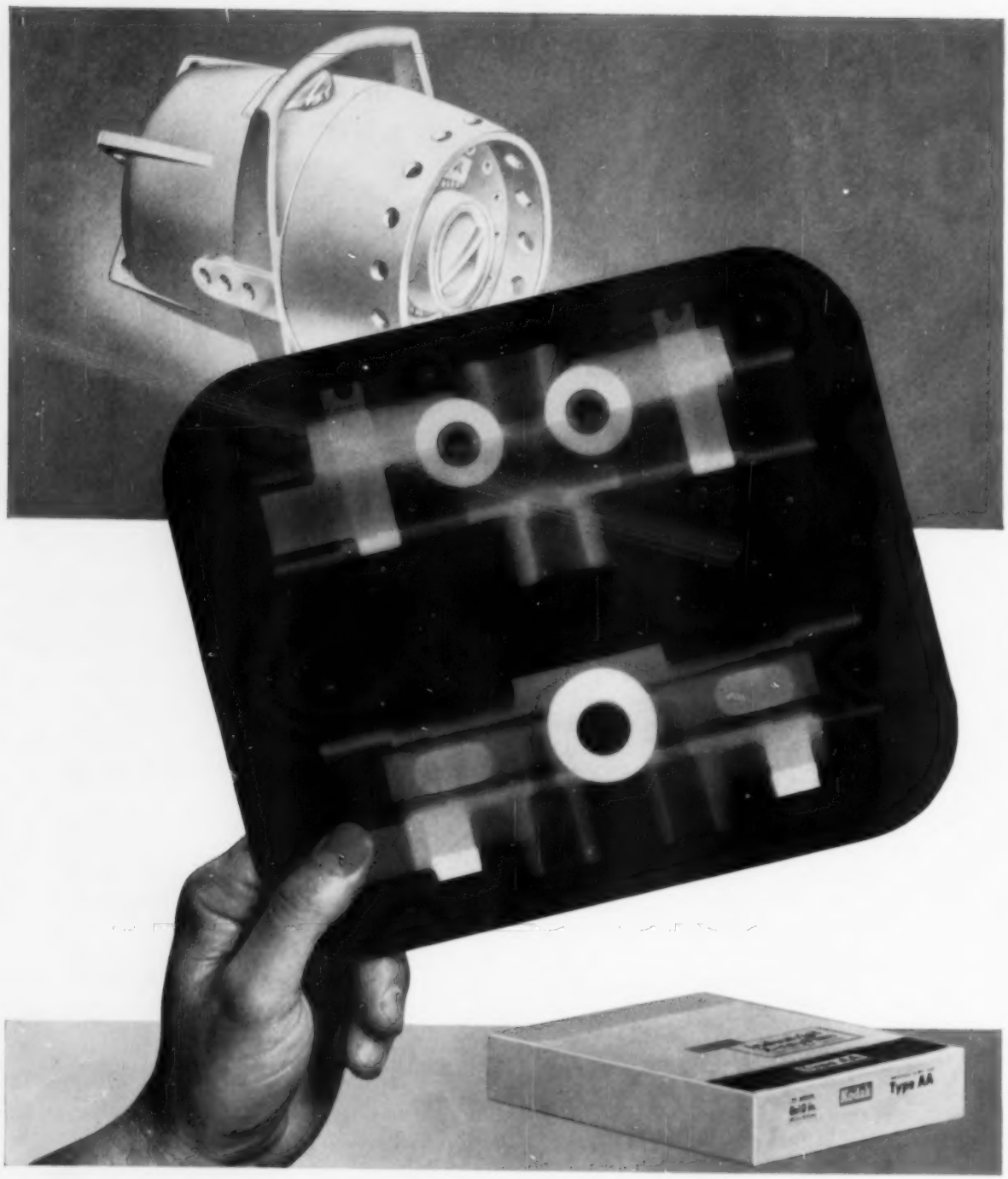

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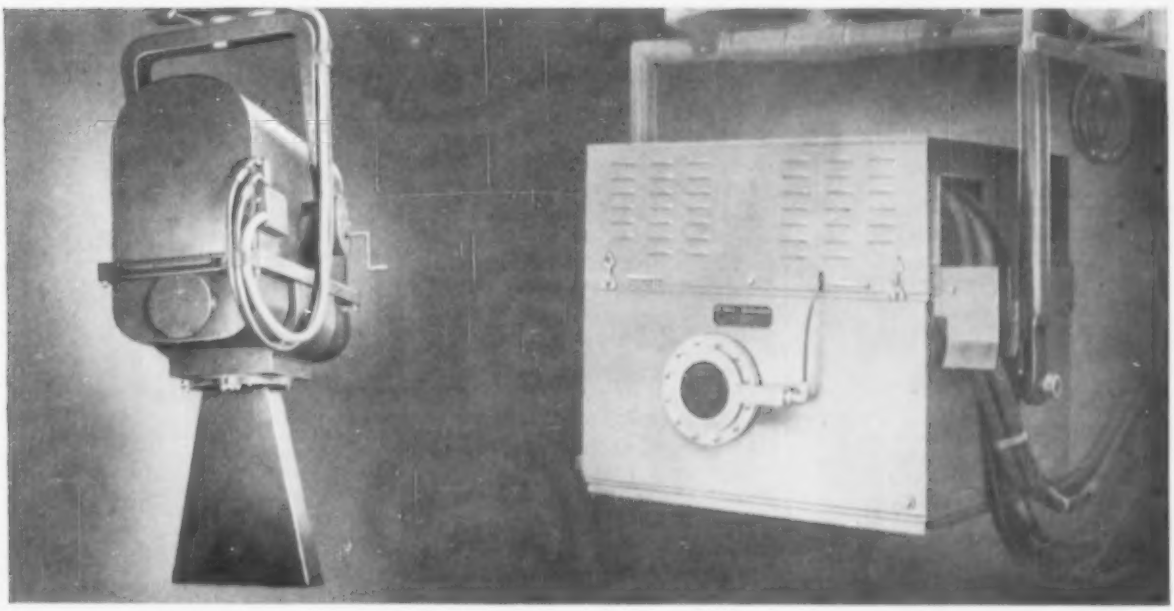

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Automation in Steel Production

Digest of "Automatic Control in the Steel Industry", by R. W. Holman, presented at the Birmingham Regional Technical Meeting of the American Iron and Steel Institute, Oct. 5, 1955, 18 p. (preprint).

CHANGES IN flat rolled steel manufacturing methods originating in the late 1920's with the shift from individual sheet processing to continuous rolling of coiled material are as significant as the much more publicized Detroit type of automation of machining processes which started in the late 1940's. For example, the old hand hot mill produced about 11 tons of sheet per turn, compared to the 550-ton turn capacity of the modern five-stand cold reduction mill — a 50-fold increase. In the old hot dip tinning processes, 33 ft. per min. was an average speed; now 2000 ft. per min. is obtained from modern electrolytic tinning lines.

Nevertheless, the industry has lagged in the adaptation of continuous automatic processing in some finishing and materials handling operations. It is recognized that a properly designed regulating control system is tireless in comparison with the human operator, has identical standards of performance from shift to shift and can make corrections for variations too small to be discerned or considered significant by the human operator. The result is better quality and improved yield, both vital factors in high-tonnage production and with relatively high product value, as is true with finished steel.

Application of controls to tandem cold reduction mills has been a highly competitive effort, resulting in a progressive advance from speeds of 1200 ft. per min. in 1935 to 7000 ft. per min. in 1955. Speed of response and accuracy of control of regulating systems are primarily responsible for the improvement. The modern tandem mill control system can correct a sudden error or changed operating condition in 0.035 sec.

Control of thickness has made significant progress, thanks to the reliability of radiation-type gages — both X-ray and nuclear source de-

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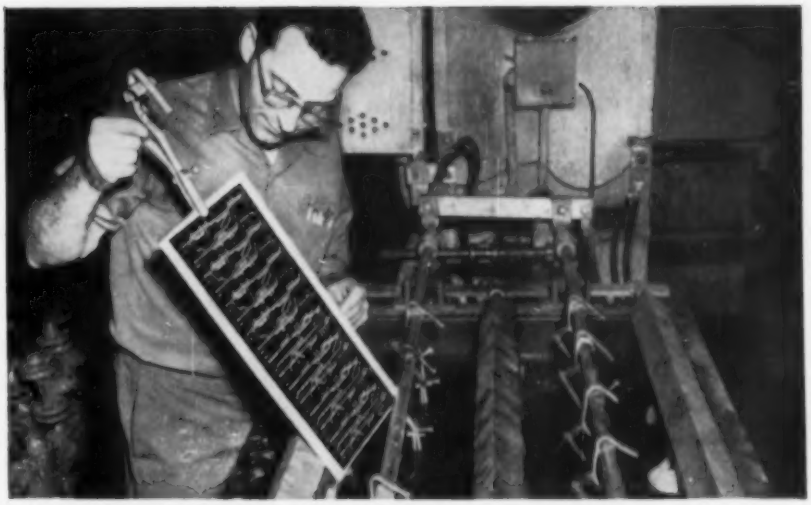

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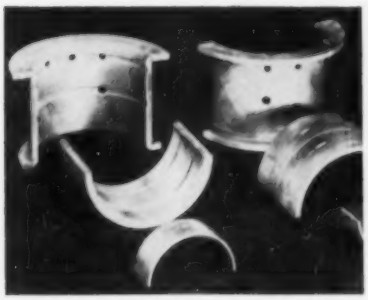

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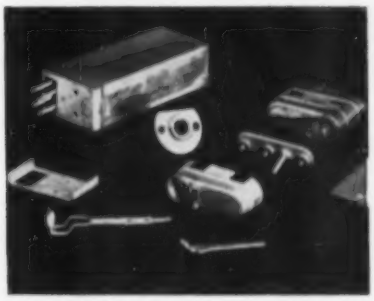

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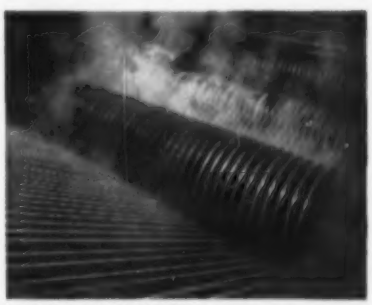

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Automation . . .

signs — and the improved design of feedback and closed-loop regulating systems. Limits of 0.0005 in. are readily maintained.

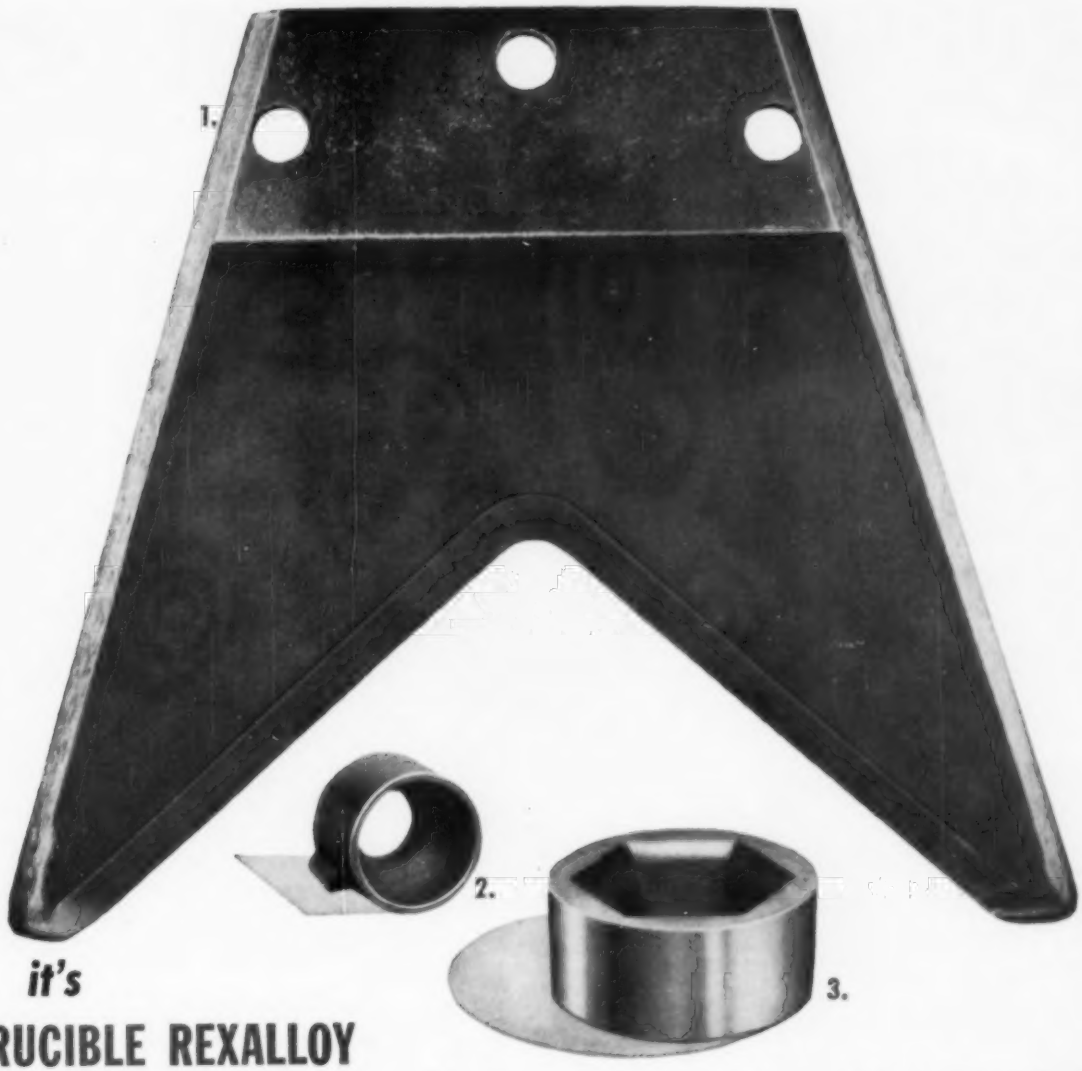
Automatic controls in coal chemical plants have made important strides. One new installation which processes raw tar and light oil from the coke-making process, and separates and purifies pitch, creosote, light oil, naphthalene, benzene, toluene and xylenes, is operated by only three men stationed at a large centralized instrument and control console 78 ft. in length.

Continuous processing of flat rolled steel, involving groups of complex interconnected operations, has fostered the development of modulated loop controls (magnetic and photo-electric), speed regulators, edge regulators, tension regulators, current regulators, temperature controllers, plating current regulators synchronized to strip speed, pinhole detectors, radiation gages, sheet classifying equipment, flow-line regulators and coating thickness recording and classifying devices. The modern processing line may have 30 separate regulating systems. The self-correcting feedback regulating system is the heart of such continuous lines.

Control systems need not necessarily be entirely electrical. Pneumatic or hydraulic actuation, or a combination of the two, is effective in many applications. One example of the pneumatic-hydraulic combination is an edge position regulator for coil edge aligning which moves recoilers and coils horizontally to follow lateral movement of the strip as it passes through the roll stands. In rolling mill research in England, consideration is being given to hydraulic cylinders to replace mill screwdowns, plus hydraulic regulating systems tied in with thickness control.

Telemetering and remote supervisory control systems have possibilities in the steel industry. One plant, for example, has under supervisory control the complete power system from 115-kv. primary power substation and power house down through the motor rooms and remote substations, including 250-v. d-c. and 440-v. a-c. distribution centers.

(Continued on p. 168)



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Automation . . .

Relays are the most used control component despite their low reliability. As long as moving parts are subject to dirt and wear, deterioration is inevitable. A large electrical manufacturer now has announced control systems without moving parts, which use magnetic amplifiers with positive feedback. They are said to be more reliable and require less space. Design of control circuits, however, is entirely different from those using relays. Model demonstration systems have been exhibited, showing complete control of the blast furnace materials handling – bins, skip hoist and bells – six-story elevator controls, machine tool controls, spot welding and punch press controls.

To make real gains in automatic manufacturing development, it is frequently necessary to rethink the process, the machine and the product. Tradition and years of practical experience are occasionally more of a hazard than a benefit to successful automation.

Designing automation equipment for any industry that attempts to imitate a man's movements and operational actions is bound to be expensive and likely will be doomed to failure.

ARTHUR H. ALLEN

Heat Treating Shell Cases

Digest of "Heat Treating Shell Cases", by L. Shiller, *Ordnance*, Vol. 39, September-October 1955, p. 358-361.

EARLY in World War II the shortage of cartridge brass forced munitions makers to use steel for shell cases. The first specimens were produced with the same methods and equipment used for brass cases with the expectation that the properties developed by cold working would be adequate. However, when the steel shells were deformed in firing tests the sidewalls did not have as much elastic recovery as the brass shells and could not be extracted from the gun. In addition there were a large number of head fractures in the first firing tests.

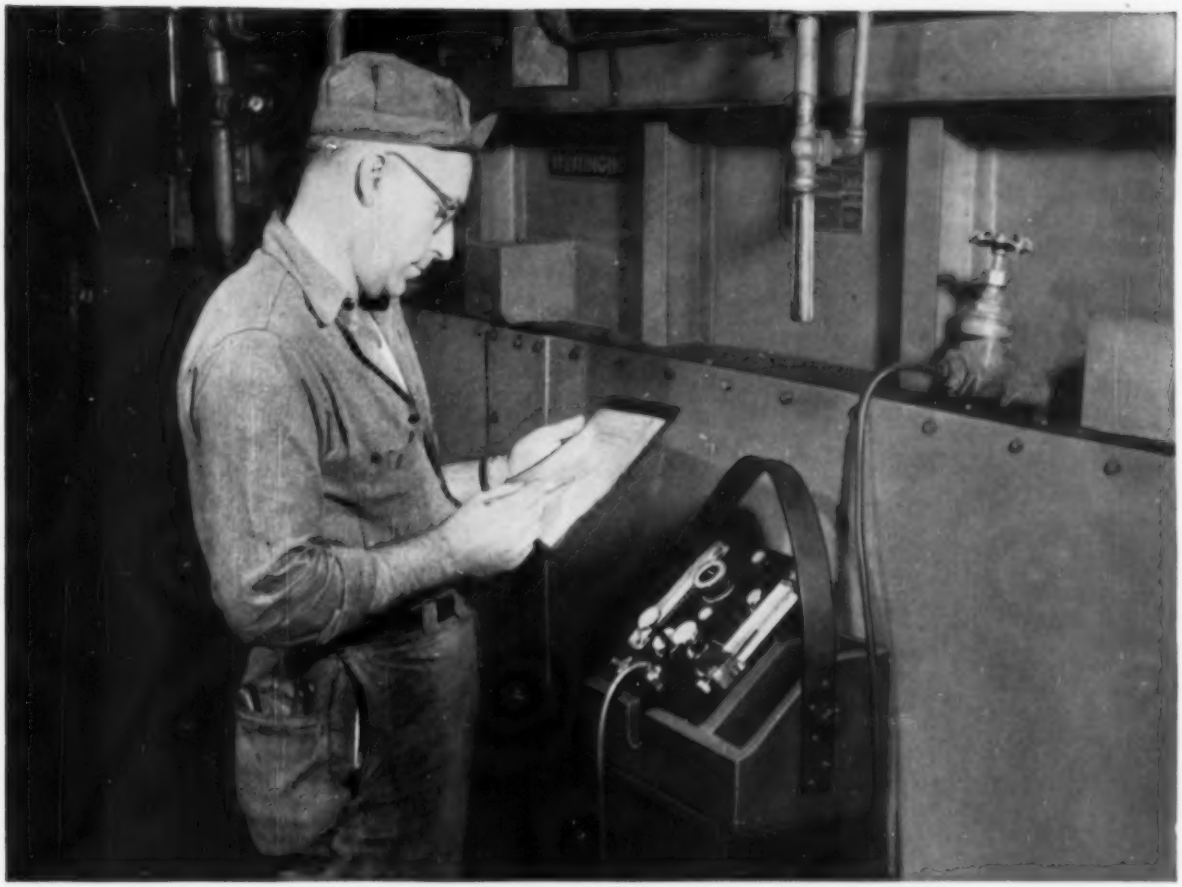
The problem of shell extraction after firing had also occurred with brass cartridge cases under some high-pressure firing conditions and the solution was to increase the yield strength by additional cold working. The most important factor is the ratio between yield strength and modulus of elasticity, which should be a minimum of 1 to 250 if the material is to be satisfactory for cartridge case sidewalls. The carbon steel which was being used could be cold worked to the necessary yield strength, 120,000 psi., but would have so little ductility that it might crack during firing. Sufficient ductility and the necessary yield strength could be obtained by heat treatment and the method finally adopted as standard practice employed a 3000-cycle induction heater.

The head fractures resulted from defects or discontinuities in the internal radius area connecting the base and adjacent sidewall. Even an apparently minor punch mark in the critical area could cause fracture. The fractures resembled impact failures and it was found that the cold worked steel had a relatively high impact transition temperature, in some instances as high as 45° F. The transition temperature at which impact failures change from ductile to brittle fracture can be lowered by proper heat treatment, so a second induction heating coil is used to heat treat the heads while the sidewalls are being treated. Gas heating has also been used for these localized heat treatments.

For small cartridge cases, 40-mm. or less, it is more economical to heat treat the entire unit than to heat only the head and sidewall. Induction, flame, controlled atmosphere and salt bath heating, or combinations of these methods, have all been successfully used, but salt baths are probably the most widely used.

An installation consists of a high-temperature salt bath, quenching tank, an intermediate-temperature salt bath for taper annealing and a conventional tempering furnace. The shell cases are austenitized at temperatures up to 1850° F. and quenched in refrigerated brine. After quenching, the shells are partially submerged in the intermediate-temperature (1025° F.) salt bath to anneal all but the critical sidewall area and head. They are then tempered to the strength level required.

B. TROCK



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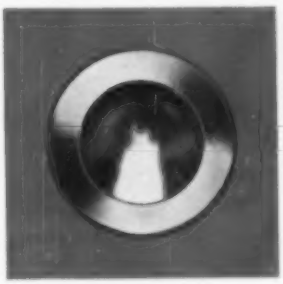

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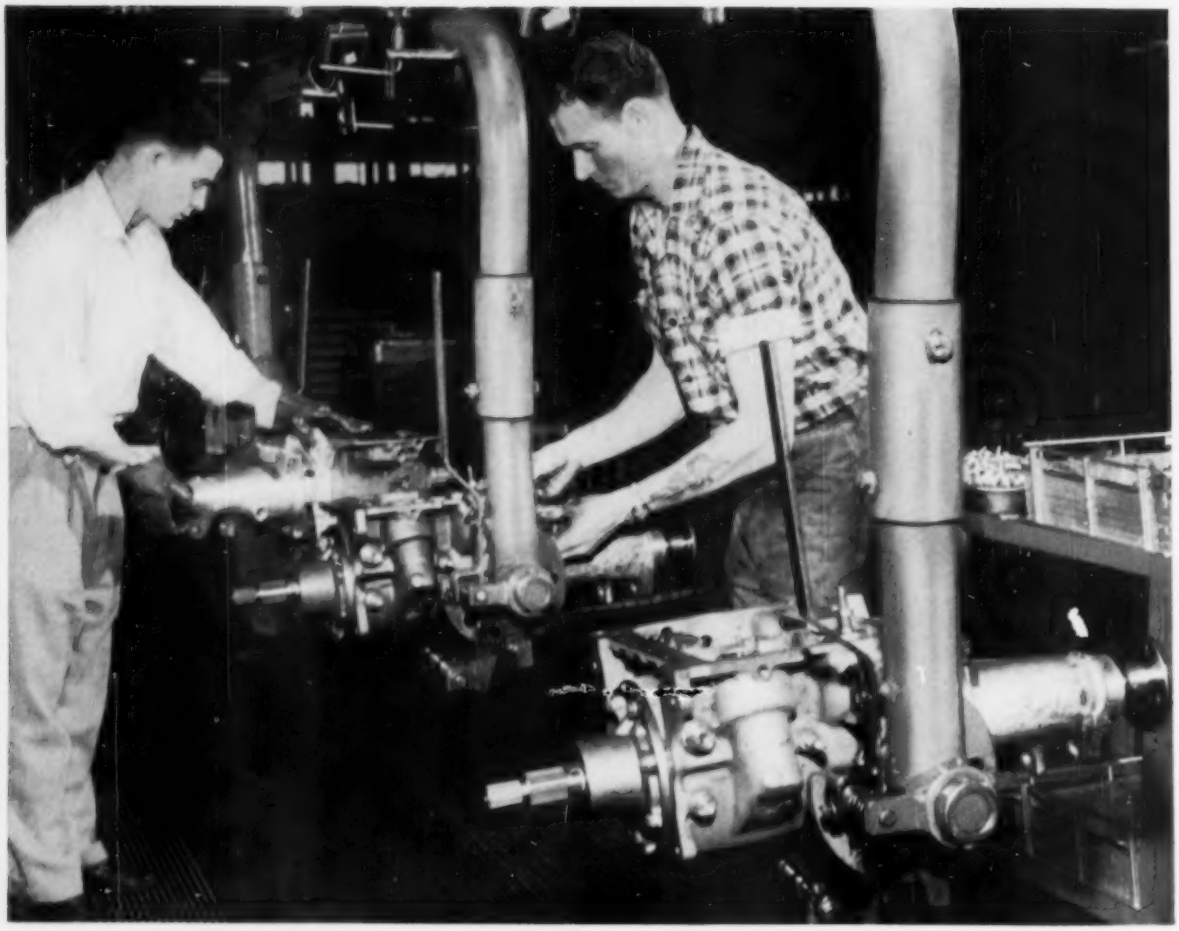


Chrysler at Indianapolis speeds precision finishing with *Lorco Compounds and Chips*

With the heavy demand for automatic transmissions, Lorco compounds and chips play an important role in the production of push-button PowerFlite transmissions at Chrysler's Indianapolis plant.

Twelve tumbling barrels for descaling, deburring, and finishing of component parts are used. Finishes and tolerances are critical. Absolute cleanliness is essential.

Using Lorco compounds, chips and precision barrel finishing techniques many hand operations are eliminated. Uniform quality and micro-inch finishes are achieved. Costs and production time are reduced.

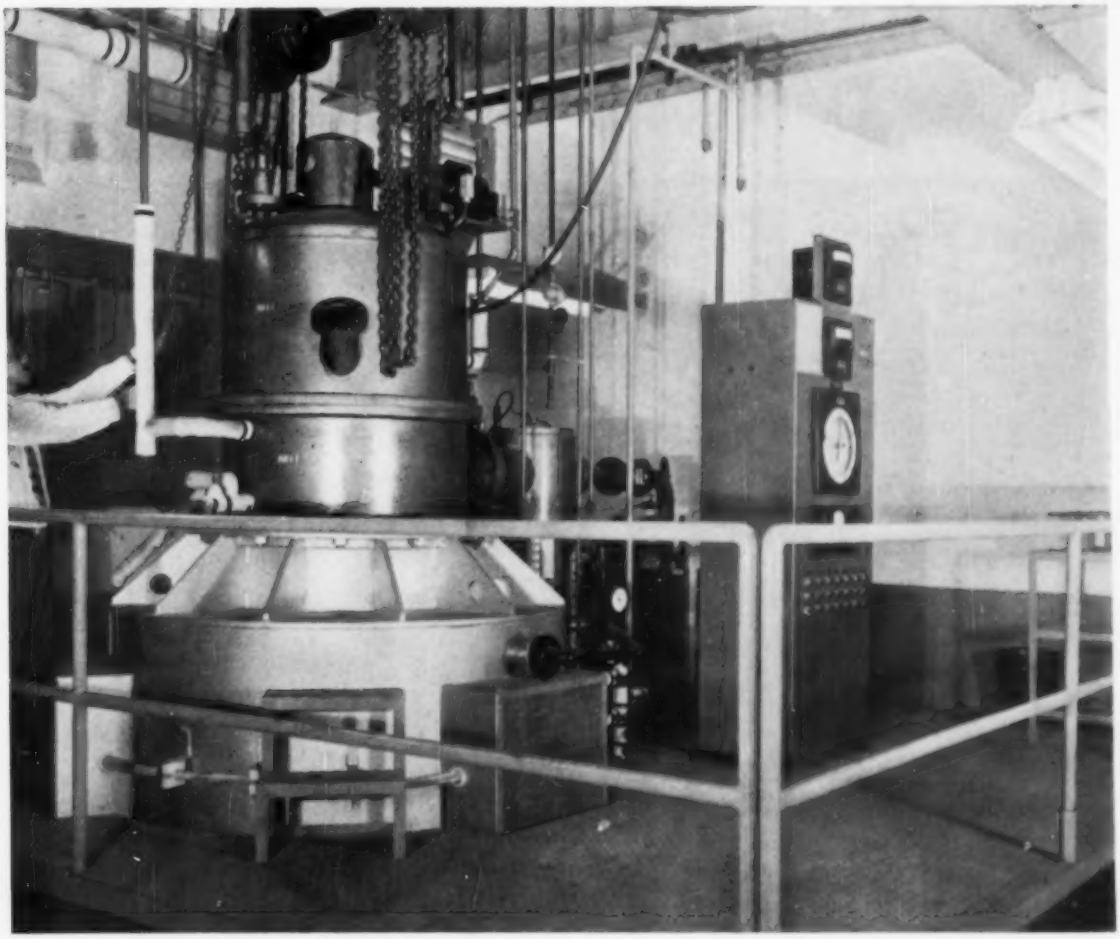
The Chrysler Indianapolis plant uses Lorco compounds and chips in finishing production of several million transmission parts each year.

This story of efficiency and quality production with precision barrel finishing and Lorco products is being repeated in many leading industries. Find out how it can apply to your operations. Write for your copy of a new, 40-page manual which provides detailed information on precision barrel finishing procedures and materials. The price is 50c postpaid.

Lord Chemical Corporation

2068 SOUTH QUEEN STREET • YORK, PENNSYLVANIA

Manufacturers of Barrel Finishing Compounds,
Tumbling Barrels, Media and Auxiliary Equipment



Costs and rejections fall substantially, thanks to this new degassing and annealing furnace with its Inconel nickel-chromium alloy retort. Using no gas atmosphere, the unit removes danger of explosions, yet its degassing capacity speeds output. Installed in plant of Raytheon Mfg. Co. Developed by High Vacuum Equipment Corp., Hingham, Mass.

Inconel retort gives safe service in high-vacuum heat treatment

HERE'S ONE OF THE FIRST large-scale vacuum heat-treating installations in the electronic field. This unit degasses steel rings for use in special-purpose power tubes.

It develops such high temperature and vacuum together that the steel readily releases impurities. Particularly gases which can spell failure if emitted during tube operation.

INCONEL the answer

Holding a vacuum of 5×10^{-4} mm Hg for 6 to 8 hours at 1850° F calls for a vessel combining great strength and heat resistance. Operators seal the work in a retort fabricated entirely of Inconel* nickel-chromium alloy.

This alloy resists damage by oxidation and carburization. It combats hydrogen embrittlement, scaling and other corrosive effects. Structurally and mechanically, Inconel nickel-chromium alloy is stable. It provides high load-carrying capacity and creep strength. In addition, it withstands thermal shock without spalling.

Readily fabricated

Measuring 48" in length with an inside diameter of 36", and made of plate 3/8" thick, this retort shows how well Inconel nickel-chromium alloy responds to fabrication. You can form, machine and weld Inconel. And it's available in all commercial wrought forms.

Write for the useful, free booklet, "Keep Operating Costs Down as Temperatures Go Up." Inconel may save you money, so write for your copy now. *Registered trademark

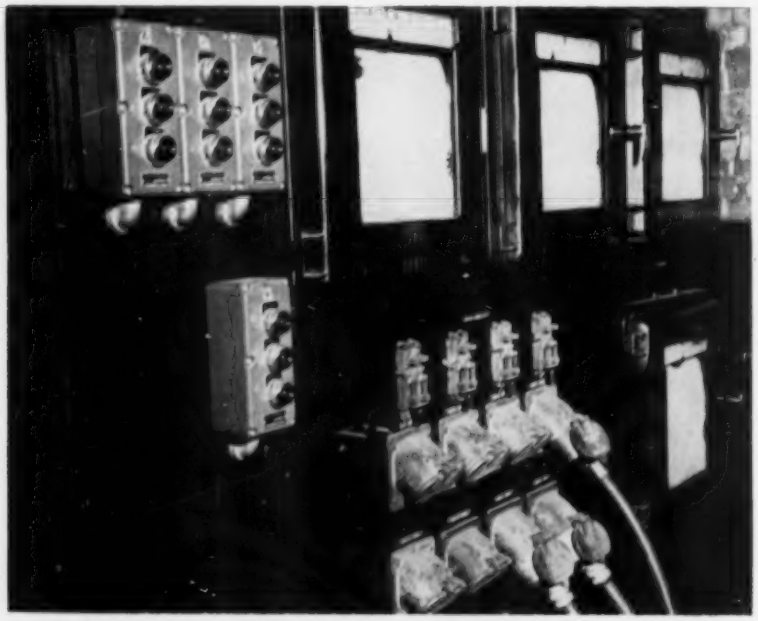
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Inconel

INCO Nickel Alloys

...for long life at high temperatures

Sharon Steel Improves Annealing Temperature Control With New Thermocouple Circuit Monitoring Device



Pushing a Restorer button on the control panel disconnects the appropriate thermocouple circuit from its pyrometer circuits and puts a test voltage on the thermocouple circuit. A red signal light indicates circuit continuity. Pyrometer readings after button is released are accurate.

Restorer Checks Thermocouples Automatically . . .

● Another leading basic steel producer uses automatic Restorer units to verify quick immersion-thermocouple checks of molten steel to be tapped from its open hearths.

Automatic Restorers use the same electrical continuity principle as manual models, but they can be preset to operate automatically. They can also be operated manually, when necessary, by a pushbutton or a key-operated switch.

Automatic Restorers are especially suited for monitoring immersion thermocouples in electric arc furnaces, induction furnaces or open hearths. These couples are often not welded and have many plug-type or screw-type connections that are common sources of poor electrical contact and excessive resistance.

The Restorer assures the accuracy of these critical temperature checks by insuring proper continuity between couple and pyrometer.

Seven coils of flat rolled strip steel are ready for annealing at Sharon Steel Corporation. Control couple near top cannot be reached for repair or replacement during heats.

Restorer Prolongs Thermocouple Life, Cuts Maintenance of TC Circuits . . .

● Closer annealing temperature control, longer thermocouple life and reduced maintenance on thermocouple circuits and pyrometers has been effected at Sharon Steel Corporation's Roemer Works, Sharon, Pa.

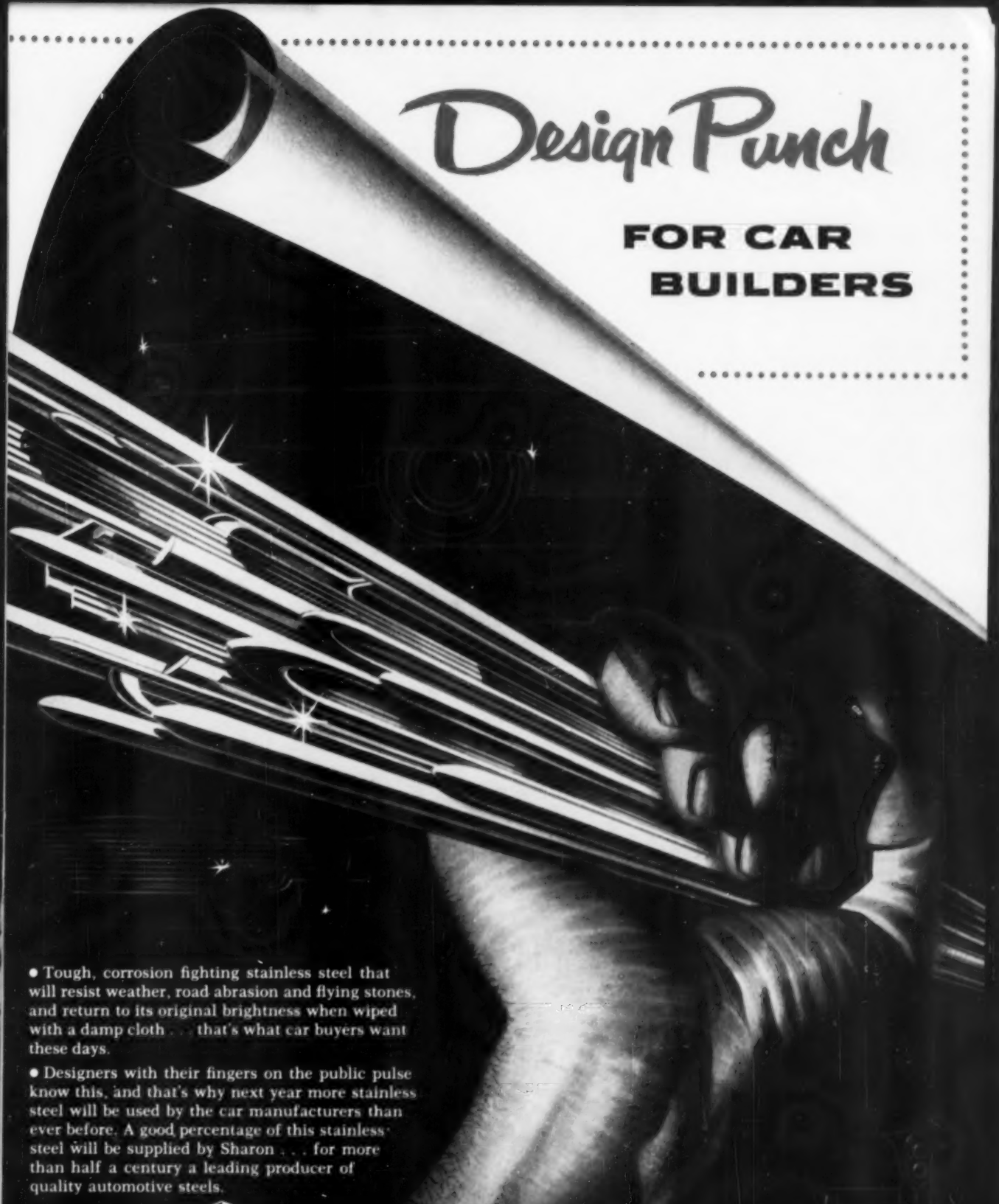
Annealing General Foreman D. H. Jones reports his furnace operators and plant instrument men have made the improvement with the aid of a device for monitoring thermocouple circuits during heat treating operations. The unit is the Restorer, produced by The Peerless Electric Company, Warren, Ohio.

The first Restorer unit, installed on trial in June, 1953, permitted Annealing personnel to repair many couple failures "on the spot" without calling instrument men. Restored couples remained accurate during heats, instead of being replaced at the first sign of failure. Less time was spent checking pyrometers because couple failures account for the majority of troubles.

Sharon Steel installed five more Restorers in late 1953 to check more than 200 thermocouple circuits on its 23 annealing furnaces. This year the firm added new units and will again install Restorer monitor stations.

The furnaces anneal flat rolled steel strip produced by Sharon Steel.

Literature available upon request.



• Tough, corrosion fighting stainless steel that will resist weather, road abrasion and flying stones, and return to its original brightness when wiped with a damp cloth . . . that's what car buyers want these days.

• Designers with their fingers on the public pulse know this, and that's why next year more stainless steel will be used by the car manufacturers than ever before. A good percentage of this stainless steel will be supplied by Sharon . . . for more than half a century a leading producer of quality automotive steels.

SHARON *Stainless Steel*

SHARON STEEL CORPORATION *Sharon, Pennsylvania*

DISTRICT SALES OFFICES: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Sharon, Seattle, Montreal, Que., Toronto, Ont.

IMPORTANT WEIGHT SAVINGS resulted from the use of magnesium in key areas of the wings and tail assembly of the Twin-Bonanza.

"MADE WITH MAGNESIUM!"

Vital parts of the new Beechcraft Twin-Bonanza are made with magnesium for extra lightness . . . extra rigidity

Six people can ride high, wide and handsome in this new Beechcraft twin-engine job. Designed for a top speed of 214 mph and a range of 1,650 miles, the stylish Twin-Bonanza is ideal for either private or company use.

To give this plane more strength for every vital pound of its weight, the manufacturer wisely chose magnesium sheet for the elevators, rudder and ailerons. Magnesium also permitted utmost simplicity of design, lower production costs—and, of course, it more than met the all-important requirement of minimum airborne weight. These are benefits of magnesium that Beech Aircraft Corporation has utilized for many years.

From ladders to truck bodies . . . if your products must be light and strong, then magnesium is *your* best choice, too. Have your design people check with your nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Magnesium Sales Department MA 350D, Midland, Michigan.

you can depend on DOW MAGNESIUM

DOW

IN THE PLANT...SHOWROOM...DRIVEWAY

everybody goes for STAINLESS STEEL!

Stainless steel means many things to many people!

To you in the industry, its exceptional versatility means almost limitless freedom. With one metal, *designers and engineers* work with beauty (set off by a wide variety of finishes), fabricating ease, remarkable structural strength, and great resistance to all weather conditions.

In production, stainless eliminates many production steps — plating or other treating operations.

To your salesmen, it's a feature they can stress. Its beauty, permanence, cleanability are helpful selling aids.

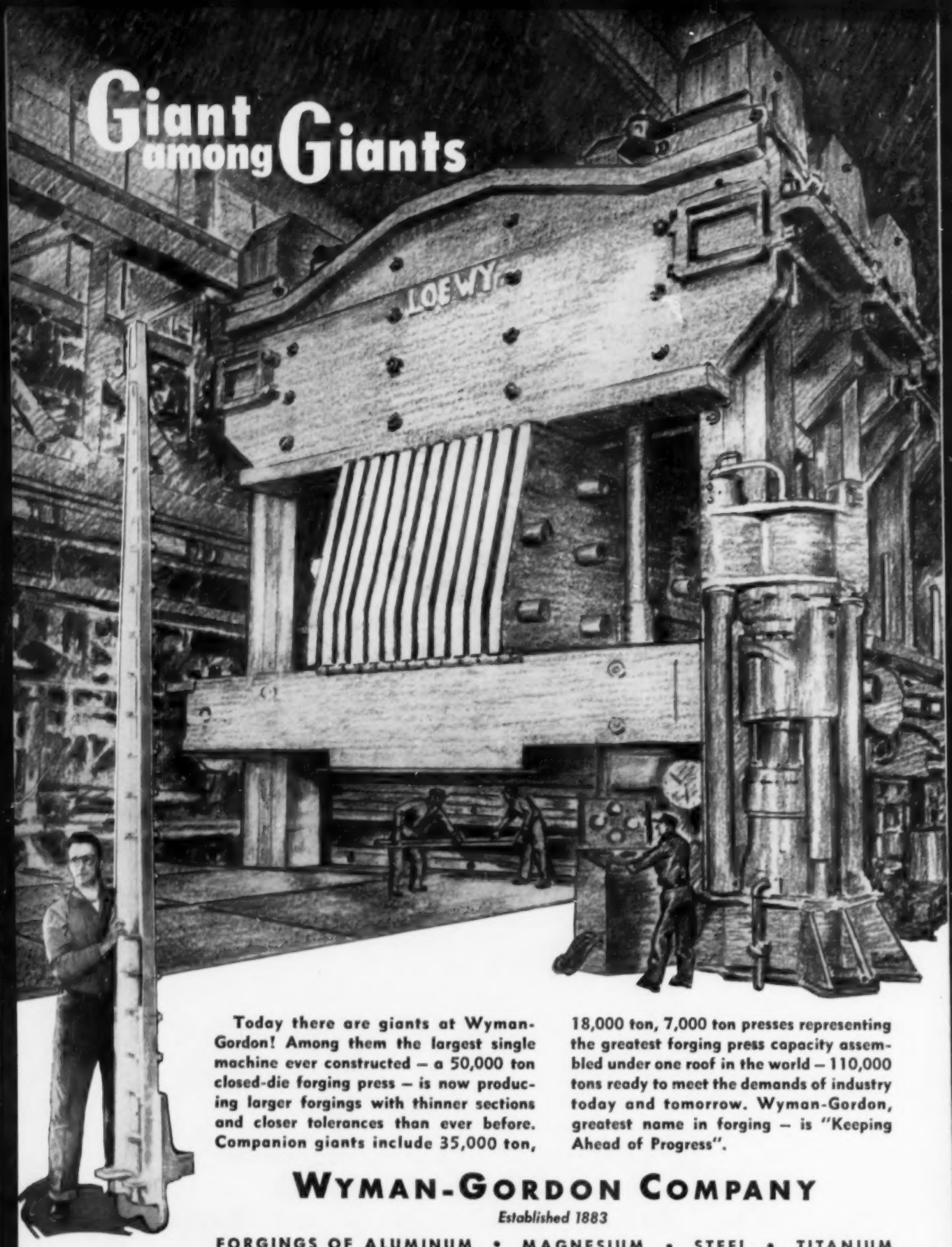
And to everybody, new and used car buyers alike, it's that series of parts that never age . . . never pit, flake or lose their sparkle. In the driveway, it makes a car a showpiece.

Why not let the Crucible engineer help you apply stainless steel profitably? *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.



Today there are giants at Wyman-Gordon! Among them the largest single machine ever constructed – a 50,000 ton closed-die forging press – is now producing larger forgings with thinner sections and closer tolerances than ever before. Companion giants include 35,000 ton, 18,000 ton, 7,000 ton presses representing the greatest forging press capacity assembled under one roof in the world – 110,000 tons ready to meet the demands of industry today and tomorrow. Wyman-Gordon, greatest name in forging – is "Keeping Ahead of Progress".

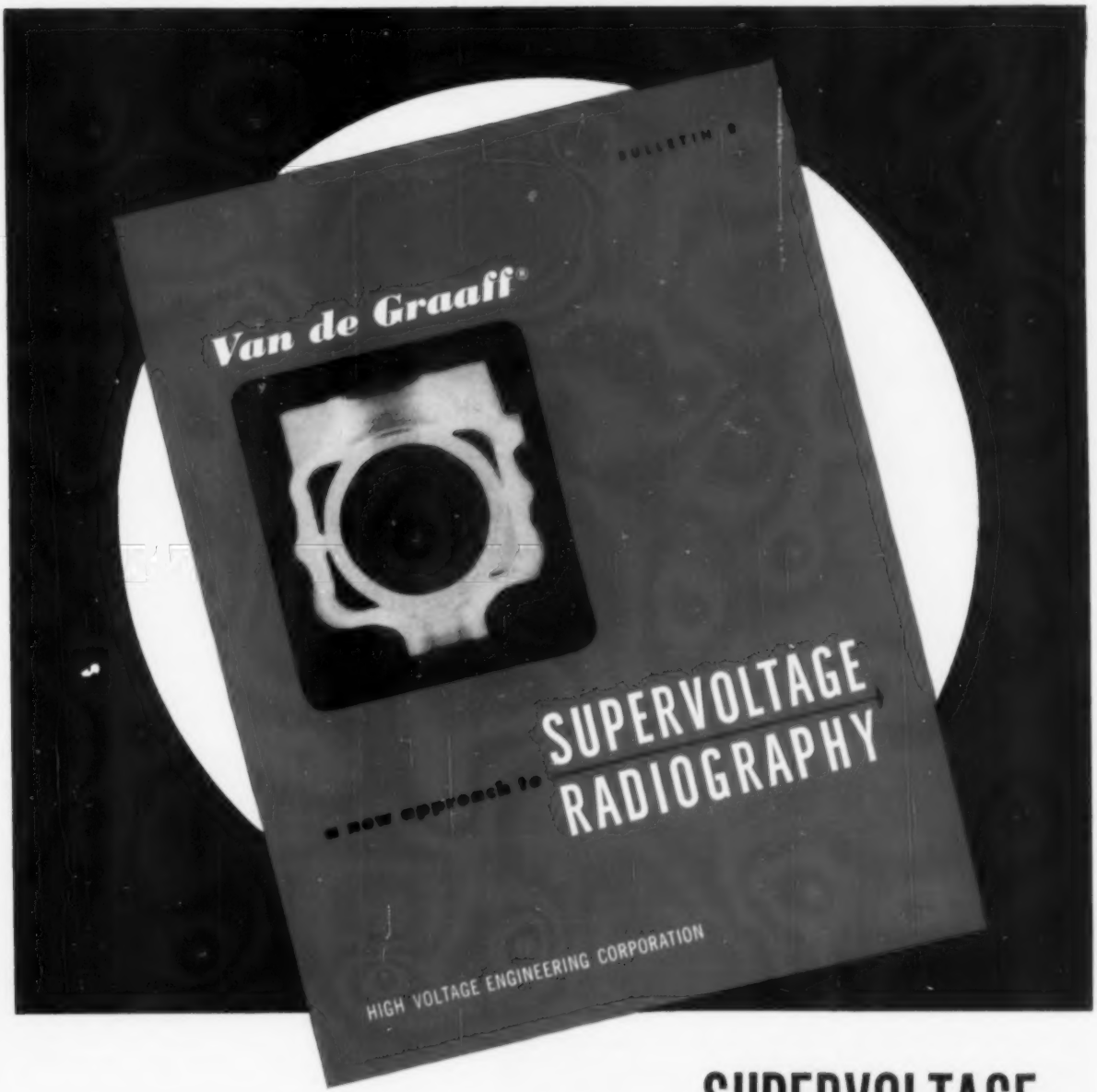
WYMAN-GORDON COMPANY

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER 1, MASSACHUSETTS

HARVEY, ILLINOIS DETROIT, MICHIGAN



Here's up-to-the-minute information on high-quality SUPERVOLTAGE RADIOGRAPHY

- *what it can do for you*
- *how it can speed up inspection*
- *where it can best be used*
- *case histories from various industries*
- *costs for equipment, installation, and operation*
- *how to choose the most economical supervoltage equipment*

Whether you need detailed data to help you choose the right equipment or to give management the facts about savings possible with supervoltage radiography, you'll find valuable information in this 28-page bulletin.

Write today for your free copy.

HIGH VOLTAGE ENGINEERING CORPORATION

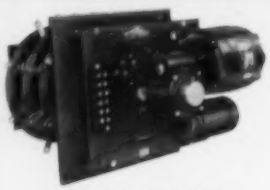
7 UNIVERSITY ROAD CAMBRIDGE 38, MASSACHUSETTS

In electroplating, anodizing, and allied processes...

Rectifier Performance Depends on Controls

MANUAL TAP SWITCH CONTROL

For both self-contained and remote controlled units. Used in conjunction with a tapped auto-transformer, it provides 22 positions of voltage adjustment from zero to rated voltage.



MOTOR-OPERATED TAP SWITCH CONTROL

For pushbutton control of output from remote location. Used in conjunction with tapped auto-transformer and it also gives 22 positions of voltage adjustment.

CONTINUOUSLY VARIABLE AUTO-TRANSFORMER

Either manual for small rectifiers, or oil-immersed, motor-driven for larger ratings. Gives full stepless control from zero to rated voltage. Highest efficiency.

SATURABLE CORE REACTOR

Wholly electrical — no moving parts. Gives smooth control from 10% to 100% of rated voltage, provided 10% minimum current load is drawn.

The selection of the proper controls with either selenium or germanium rectifiers can be the key to improving your plating and anodizing results. For every installation there is a control which will best fit the application. Let H-VW-M make an engineering survey and recommend the most suitable control to give you not only the best results, but also the maximum in efficiency, flexibility, and economy.

APPLICATION SUGGESTIONS

Use	Recommended Control
Batch Tank Plating	Manual tap switch.
Batch Tank Plating with wide load variations and high production	Motor operated variable auto-transformer or motor operated tap switch.
Barrel Plating	Manual tap switch. No control rectifier.
Cleaning & Pickling	Manual tap switch. No control rectifier.
Conveyor—many stations	Manual tap switch (remote control). Motor operated tap switch. Saturable core reactor. Motor operated continuously variable auto-transformer.
Conveyor—few stations	Automatic voltage stabilization with variable auto-transformer. Automatic voltage stabilization with saturable core reactor.
Chrome strike in combination with Plate	Automatic programming with variable auto-transformer or special series hook-up.
Sulphuric Anodizing	Manual tap switch. Motor operated tap switch. Saturable core reactor.
Color Anodizing	Automatic constant current with variable auto-transformer. Automatic constant current with magnetic amplifier and saturable core reactor.
Chromic Anodizing	Automatic programming with variable auto-transformer. Combination automatic constant current and automatic voltage stablization with variable auto-transformer or saturable core reactor.
Electrolytic Metal Refining	Automatic current control with saturable core reactor.

3110

Need Automatic Voltage Stabilization?

For close DC voltage regulation, automatic voltage stabilization will maintain voltage at pre-set level. Use either sensing panel with motor-driven, oil-immersed continuously variable auto-transformer, or special magnetic-amplifier with saturable core reactor. H-VW-M controls can also provide automatic constant current.

Need Automatic Programming?

Motor-operated continuously-variable auto-transformers, plus timers and controls, will set voltage and operate for pre-set time; change to another voltage at pre-set rate; operate at new voltage for given time, then shut the rectifier off.

PLATEMANSHIP

SEND TODAY for free Bulletin ER-108 describing H-VW-M SELENIUM and GERMANIUM Rectifiers and H-VW-M's full line of controls.

Your H-VW-M combination — of the most modern testing and development laboratory — of over 80 years experience in every phase of plating and polishing — of a complete equipment, process and supply line for every need.

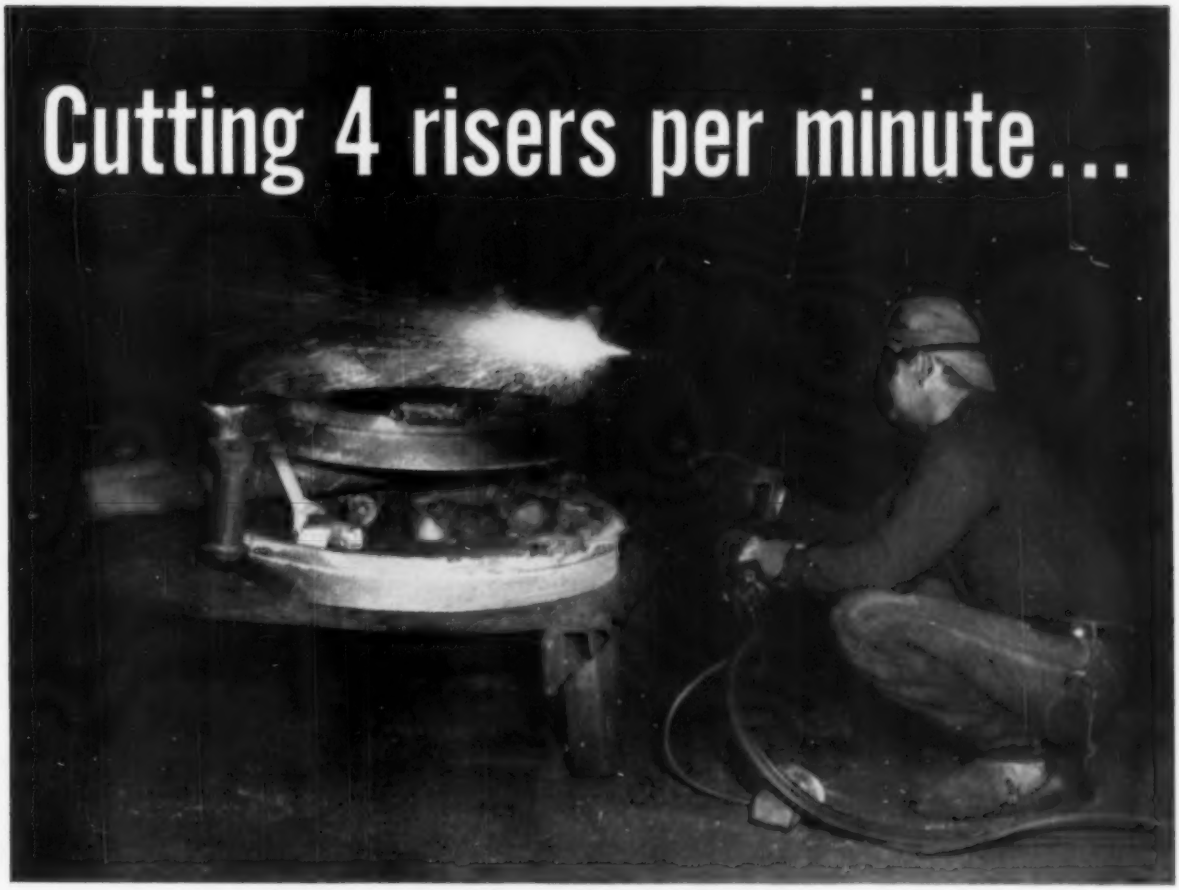
HANSON-VAN WINKLE-MUNNING COMPANY, MATAWAN, N. J.
Plants: Matawan, N. J. • Grand Rapids, Mich.

SALES OFFICES: Anderson (Ind.) • Baltimore • Beloit (Wisc.) • Boston Bridgeport • Chicago • Cleveland • Dayton • Detroit • Grand Rapids • Los Angeles • Louisville • Matawan • Milwaukee New York • Philadelphia • Pittsburgh • Plainfield • Rochester St. Louis • San Francisco • Springfield (Mass.) • Utica Wallingford (Conn.)

H-VW-M

INDUSTRY'S WORKSHOP FOR THE FINEST IN PLATING AND POLISHING PROCESSES • EQUIPMENT • SUPPLIES

Cutting 4 risers per minute...



Lightweight and easy to handle, this OXWELD powder-cutting blowpipe makes fast work of risers.

Powder-Cutting speeds removal operations 300%

Removing risers from stainless steel castings need no longer be costly and time consuming. Pictured above is a typical powder-cutting operation at the Ohio Steel Foundry Company, Springfield, Ohio. Here, 2 by 4 inch thick stainless steel risers are removed by powder-cutting in only 15 seconds. By methods previously used, this operation took up to four times longer.

In the powder-cutting process metal powder is automatically injected into an oxygen flame to increase the flame's heat and severing action speed. The powder process is helping users gain new efficiency and speed in the removal of gates and risers, sand incrustations, and casting defects.

The powder-cutting blowpipe used in this operation, an OXWELD AC-4, is designed for hand cutting of oxidation resistant metals such as stainless steel, chrome alloys, and cast iron. Heavier apparatus is also available for manual and mechanized operations.

Increase your production and profit—call your local LINDE representative, or write for illustrated literature on LINDE's modern processes. Start saving now, do it today.

Linde Air Products Company
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto

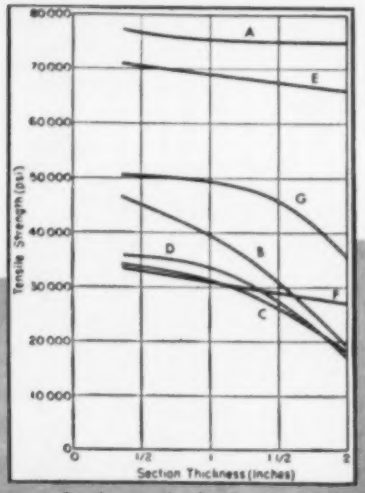
Linde Trade-Mark

"Linde" and "Oxweld" are registered trade-marks of Union Carbide and Carbon Corporation.

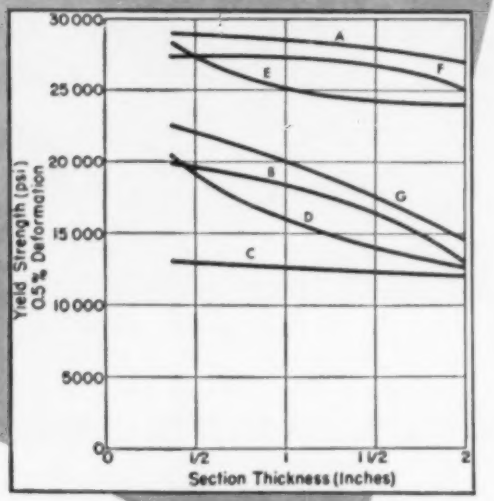
Here's proof....

that you can use lighter sections, have greater strength, improve your product, save money

with AMPCO* Metal



Tensile strengths of various non-ferrous metals vs. section thickness



Yield strengths of various non-ferrous metals vs. section thickness

Examine these charts carefully — they tell a story that can save you money and put extra life and dependability into your product.

Look, for instance, how other non-ferrous metals show a sharp decrease in mechanical values as casting cross-sections increase. Ampco remains practically constant — you require less metal.

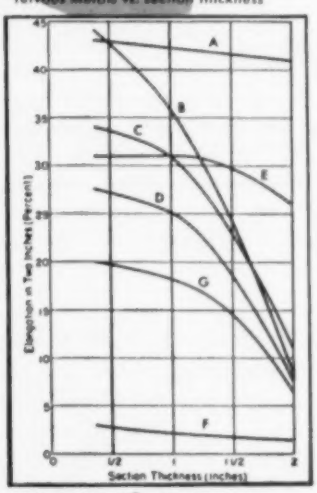
Note Ampco's unusually high tensile and yield strengths compared with conventional bronzes — you use lighter sections to do a better job. And Ampco Metal weighs 10 to 15 percent less than other bronzes — so you can make important weight reductions.

Fact is, Ampco Metal's high strength-to-weight ratios can mean real savings for you — savings in material and money. Consult your nearby Ampco field engineer for full information or write us.

CHART REFERENCE

- A. Ampco Metal
- B. Tin Bronze (88-8-4)
- C. Red Brass
- D. Tin Bronze (85-5-5-5)
- E. Manganese Bronze
- F. Aluminum Alloy
- G. Silicon Bronze

Charts courtesy Materials & Methods and Westinghouse Electric Corp



Elongations (2") of various non-ferrous metals vs. section thickness

AMPCO

Sole Producer of Genuine Ampco Metal

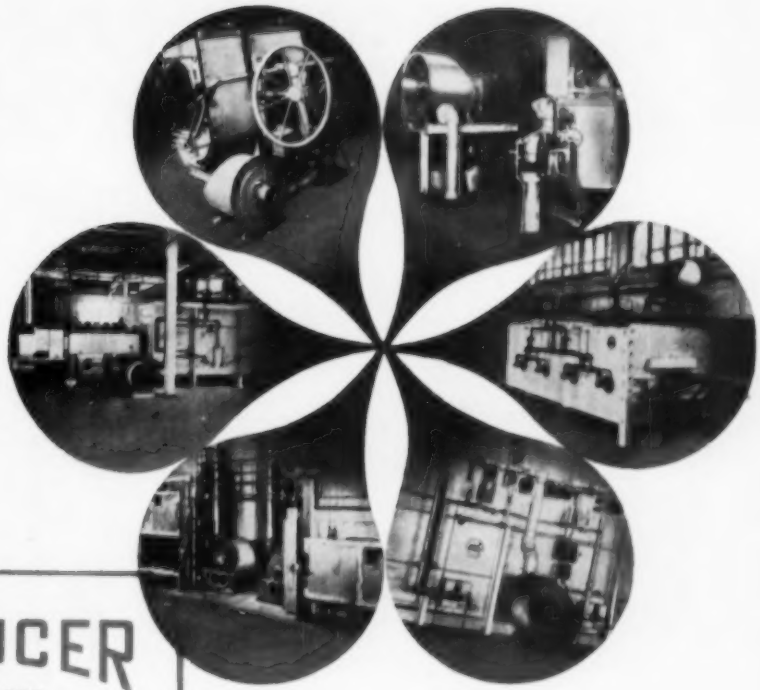
AMPCO METAL, INC.

Dept MP-5, Milwaukee 46, Wisconsin

West Coast Plant: BURBANK, CALIFORNIA

*Reg U S Pat Off

D-43



SPENCER
HARTFORD
TURBOS

The illustration shows Rockwell furnaces for carburizing, crucible melting, bright annealing, casting annealing, aluminum annealing and coil wire annealing—all equipped with Spencer Turbo-Compressors.

are recommended by

THE W. S. ROCKWELL CO.

Since 1918, now more than a quarter of a Century, Rockwell has recommended Spencer Turbos in connection with their furnaces and ovens. A few recent installations are shown above.

Spencer Turbos have met the test of time—in years and in continuous service with a minimum of shut downs and maintenance costs. The simplicity of design with wide clearances, low peripheral speeds and only two bearings to lubricate is partly responsible. Other features are described in Bulletin No. 126-A illustrated below.

THE SPENCER TURBINE COMPANY

SPENCER
HARTFORD

HARTFORD 6
CONNECTICUT

494-A

Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners

TRY ANY UNITRON METALLURGICAL MICROSCOPE FREE for 10 Days!

LET THE INSTRUMENT PROVE ITS VALUE TO YOU BEFORE YOU DECIDE TO PURCHASE

See for yourself why more and more of our leading industrial firms, universities and research laboratories are turning to UNITRON microscopes. These remarkable instruments have dispelled the myth that unexcelled optical and mechanical performance is inconsistent with low cost. Try one of these microscopes in your own laboratory for ten days. There is no cost or obligation. Verify its fine optical and mechanical performance.

UNITRON Metallurgical Microscopes are chosen by such leading firms as . . .

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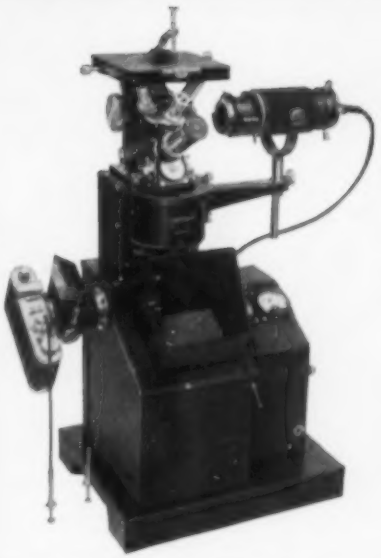
National Bureau of Standards
International Nickel
Firth Sterling
Raybestos-Manhattan
U.S. Dept. of Agriculture
Colorado School of Mines
General Electric
American Brass
Minneapolis-Honeywell Regulator
Procter & Gamble
Glenn L. Martin Co.
E. I. DuPont de Nemours
International Business Machines
National Cash Register Corp.

THIS COMPLETE CATALOG ON UNITRON MICROSCOPES IS YOURS FOR THE ASKING

This colorful, illustrated catalog gives complete specifications on all of the instruments briefly described on this page, as well as others which we know will interest you. Send coupon below for your free copy.



UNITRON METALLOGRAPH and UNIVERSAL CAMERA Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 8 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 25-2000X.
- Compact and entirely self-contained with built-in 3¼" x 4¼" camera, high-intensity illuminator, variable transformer.
- The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
- Transmitted light accessories for transparent specimens included.
- Calibrated square mechanical stage with calibrated rotatable stage plate.
- Many other important features and accessories including calibrated polarizing apparatus, filters, micrometer eyepieces, film holders, etc. Cabinet.
- Additional accessories include: Polaroid Land Camera attachment; 35 mm camera attachment; low-power (5-40X) objectives; available at extra cost.

COMPLETE UNIT only fob Boston **$1145.**

BINOCULAR MODEL, BU-11 only $1319.

UNITRON LABORATORY MODEL MMU

UNITRON Model MMU pioneers several new features available for the first time and, in addition, includes features found only in instruments selling for well over twice our unusually low price. For metals and other opaque specimens under both ordinary and polarized light. This model far surpasses the usual metallurgical microscope in versatility and makes an ideal all-purpose laboratory microscope. Its features include:

- transformer built into microscope base.
- vertical illuminator with iris diaphragm and filters.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coated optics.
- coarse and fine focusing.
- focusable stage.
- calibrated drawtube.
- polarizing apparatus and 5 filters.
- revolving nosepiece with objectives 5X, 10X, 40X, 100X, oil.
- eyepieces: P5X, P10X, K15X.

COMPLETE, only **$287.**

UNITRON STUDENT MODEL MMA

UNITRON Model MMA is a complete and versatile metallurgical microscope priced at about the usual cost of an accessory vertical illuminator needed to adapt an ordinary microscope for work with opaque specimens. Model MMA offers many of the novel features of the larger Model MMU insofar as these features are not connected with the higher magnifications obtainable with an oil-immersion lens. Its low cost makes the MMA ideal for student use and routine laboratory investigations. Its features include:

- transformer built into microscope base.
- vertical illuminator with iris diaphragm.
- illuminator mounts on stage for oblique lighting.
- illuminator mounts substage for transparent specimens.
- coated optics.
- single focusing control
- substage 5-hole disk diaphragm.
- frosted filter
- revolving nosepiece with objectives 5X, 10X, 40X.
- eyepieces: H5X, P8X, K15X.

COMPLETE only **$149.**

UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of opaque specimens. 25-1500X.

- transformer built into microscope base.
- vertical illuminator with iris diaphragm.
- coarse and fine focusing.
- filters: polaroid, frosted, blue, green, yellow.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- coated optics
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: P5X, Micrometer 10X, K15X.

COMPLETE only fob Boston **$319.**

Binocular Model, only $493.

United Scientific Co.

204 Milk Street, Boston 9, Mass.

Please send us your complete catalog on UNITRON Microscopes.

Name .....

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Company .....

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United Scientific Co.

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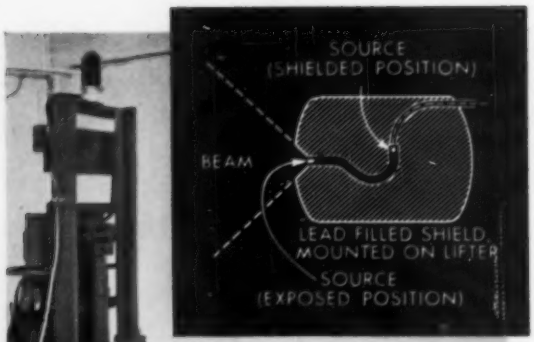
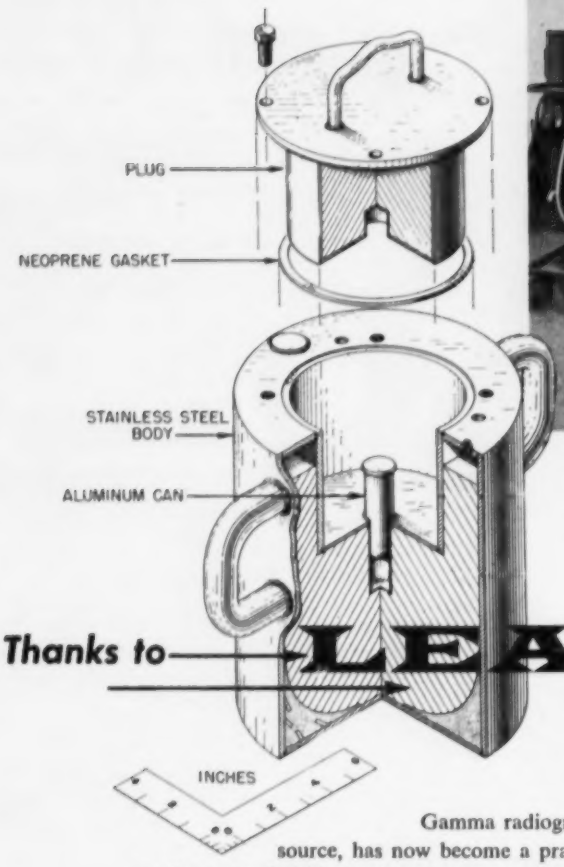




Above: Directional gamma radiography equipment is shown in the photograph. The drawing shows how the lead container serves both to direct the rays and to shield personnel from dangerous radiation exposure. *Courtesy: Technical Operations, Inc.*

Left: Returnable container for Cobalt 60. *Courtesy: Oak Ridge Nat'l. Laboratory*

Thanks to LEAD — *Co⁶⁰ is becoming industry's "seeing-eye" in non-destructive testing!*

Gamma radiography, utilizing Cobalt 60 as the self-generating "light" source, has now become a practical and low-cost industrial tool in the vital field of quality control. This has been made possible by (a) the availability of Cobalt 60 from the nation's nuclear reactors and (b) by taking advantage of the inherent and incomparable density of the metal lead as a material of construction for portable "safes" containing Cobalt 60 or other high-energy radioisotopes. As a shielding material, lead prevents off-target penetration of the dangerous gamma rays. The thickness of the lead shield is, of course, governed by the penetrating power of the rays emitted. Oak Ridge National Laboratory specifications for a Cobalt 60 container read as follows:

TYPE OF CONTAINER	TYPE OF MATERIAL SHIPPED	MAXIMUM ACTIVITY		THICKNESS OF LEAD SHIELD (in.)	TOTAL WEIGHT OF ASSEMBLED CONTAINER (lb)
		Radioisotope	Amount		
Returnable	Unseparated solids, gamma emitters	Co^{60}	1 curie	4	450
			5 curies	5	660
			25 curies	6	810
			100 curies	7 1/2	1320

The property of density has made lead, one of the first metals utilized by man, an important factor in a new and rapidly expanding industry with unlimited potentials... the harnessing of nuclear energy.

TYPICAL APPLICATIONS INCLUDE:

- Heat Treating
- Sintering
- Brazing
- Annealing
- Ceramic Firing
- General Research

NEW TECHNICAL BULLETIN on TUBULAR HEATING ELEMENTS

AUTHORITATIVE... COMPLETE

A 12-page catalog devoted exclusively to non-metallic tubular heating elements ... physical and electrical specifications, electrical connections, mounting and control methods, applications.

BULLETIN "M" is designed to give you detailed information about tubular heating elements... made only by GLOBAR Division of The Carborundum Company. In modern electric tube furnaces, they are used as the *furnace chamber* as well as the *source of heat*... provide uniform temperatures up to 3000° F... give maximum efficiency and economy in laboratory and pilot plant work, and in the production firing of small parts.

MAKE SURE YOU HAVE YOUR COPY! Find out how GLOBAR® Silicon Carbide Tubular Heating Elements can serve your high temperature heating needs...with profit. Get your copy of Bulletin "M" by writing The Carborundum Company, Dept. MP 87-610, Niagara Falls, New York

Globar®

30 Years of Heating Element Experience

IN ELECTRIC-WELD PIPE AND TUBE MAKING

Yoder leads the way

to higher speeds and quality at lower cost

In the short period from 1938 to 1955, the production of electric welded pipe and tubing grew from 269,000 tons to over 3,000,000 tons. This phenomenal rate of growth—over two and one-half times faster than that of the pipe and tube making industry as a whole—to a large extent resulted from a series of important improvements in tube mill design, all introduced by Yoder.

First came the Yoder rotating welding transformer, in 1938. The economic and other benefits conferred by this epoch making innovation were further augmented by other technological advances scored by Yoder in the years that followed. The result was that electric-weld pipe and tube making became the child prodigy of the fast growing pipe and tube making industry.

Latest, and perhaps the greatest, of these developments is the cold forming and induction welding at high speeds of *aluminum, magnesium, brass, nickel, monel, and other non-ferrous metals and alloys*. This process is especially economical for making light and medium gauge tubes in sizes up to 8 in. dia. More and more leading non-ferrous metal producers and fabricators are installing these mills.

More complete information about this and other interesting Yoder developments in pipe and tube mill equipment may be had merely by asking for any of the following publications:

- ☐ Resistance-Weld Mills for making Steel Tubing up to 4" diameter.
- ☐ Induction-Weld Mills for making Non-ferrous Tubing.
- ☐ Resistance-Weld Mills for Steel Pipe up to 24" diameter.

THE YODER COMPANY

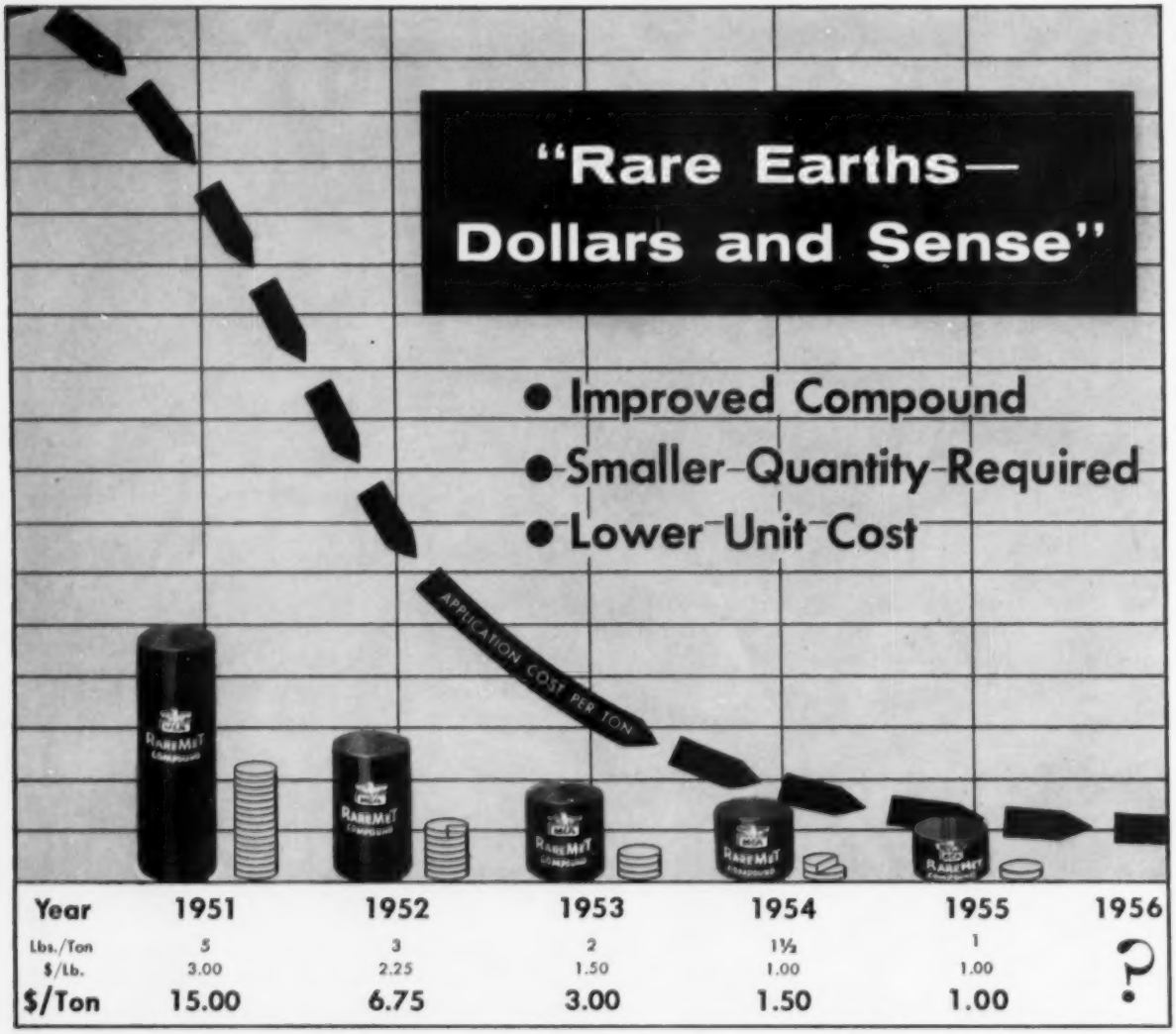
5595 Walworth Avenue **Cleveland 2, Ohio**

ENGINEERING YODER MANUFACTURING

PIPE AND TUBE MILLS—Electric Weld

ROTARY SLITTING LINES

COLD ROLL FORMING MACHINES



Year	1951	1952	1953	1954	1955	1956
Lbs./Ton	5	3	2	1½	1	
$/Lb.	3.00	2.25	1.50	1.00	1.00	
$/Ton	15.00	6.75	3.00	1.50	1.00	?

So rapid has been the advance in technical progress and use of rare earths (Trade Name: MCA RareMeT Compound) that in the brief span of four years, about one-fourth as much is needed to accomplish the desired results, at one-third the cost per pound. Now, the economics in favor of rare earths are ten times as great as they were four years ago.

In OPEN HEARTH STEELS, the improvement in addition practice is making rare earths more and more economical, actually cutting production costs. Excellent results with STAINLESS STEEL in hot workability and increased yield have been verified consistently.

Most steel producers, conscious of their customers' increasing demands for better quality, greater uniformity, and consistently good iron and steel are actively engaged in research employing rare earths. If the cost of iron and steel producing is at all interesting to you, or if customer rejections play any part in your operations, it will pay you to investigate the intelligent use of MCA RareMeT Compound. A letter addressed to any office will bring prompt and confidential response.

MCA

MOLYBDENUM

CORPORATION OF AMERICA

Grant Building Pittsburgh 19, Pa.

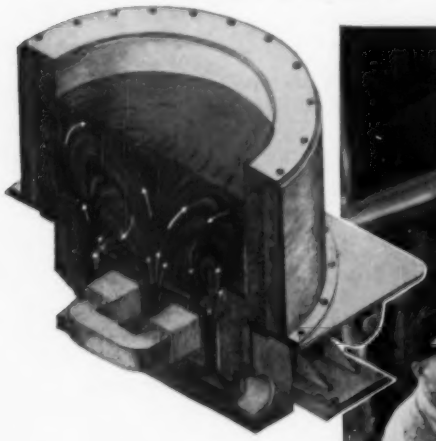
Offices: Pittsburgh, Chicago, Detroit, Los Angeles, New York, San Francisco
Sales Representatives: Edgar L. Fink, Detroit; Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland Plants: Washington, Pa., York, Pa.

HARD-TO-MELT BRONZES SUCCESSFULLY HANDLED

in

AJAX INDUCTION FURNACES

Brass and bronze foundries all over the country have found AJAX-TAMA-WYATT induction furnaces a reliable tool for melting silicon bronzes, aluminum bronzes, leaded bronzes, phosphor bronzes, and other high strength alloys. Operation is highly economical due to the good uniformity of the alloys, low ratio of rejects, drastic reduction of metal losses, and clean operating conditions. This recent development opens the field for the use of AJAX induction furnaces in all foundries where difficult-to-melt alloys are handled.



Cross section of AJAX-TAMA-WYATT twin coil induction furnace such as used at the Torrance Brass Foundry. Heat is produced within the molten metal in the secondary channels and conveyed throughout the melt by electromagnetic circulation, resulting in minimum metal losses and high uniformity of alloy. Temperature is automatically controlled.

Baseball Fans—Do you recognize this man? He is Rocky Bridges, Cincinnati Redleg infielder, keeping in condition during the Winter season at Torrance Brass Foundry, Torrance, Cal.

(Photograph courtesy of Long Beach Press-Telegram, Long Beach, Calif.)

The furnace pictured above is melting aluminum bronze at the **Torrance Brass Foundry, Torrance, Cal.**, operating at a temperature of 2400 F, for the production of high strength centrifugal castings. This unit is rated 100 kw. Note also the clean, smokeless operation as shown in the unretouched photograph.

AJAX ENGINEERING CORP., TRENTON 7, N. J.

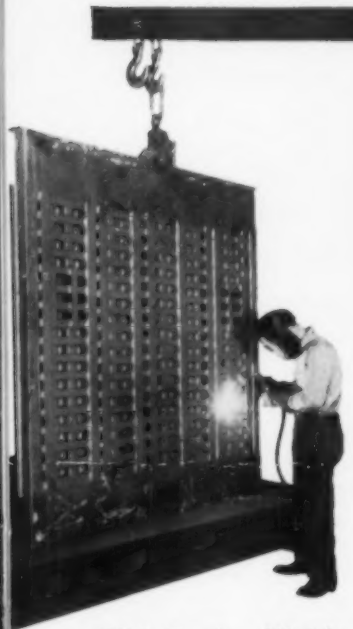
AJAX TAMA-WYATT = **INDUCTION MELTING FURNACE**

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...

. . . Lops Off 1,047 Lbs.

Trays for ore clean-up buckets need tremendous resistance to impact, abuse, and abrasion. Blaw-Knox Company, Pittsburgh, Pa., found that they weigh half a ton less, and cost less to fabricate when made from USS "T-1" Steel plate instead of heavy steel castings.



. . . 534 Easier Welds

This printing press bedplate manufactured by Graver Tank & Manufacturing Co., Inc., must be welded in 534 places. High alloy steel with the needed strength was very difficult to weld. But USS "T-1" Steel is easy to weld . . . and has the needed strength to keep these bedplates, used on high-speed printing presses, as lightweight as possible.

Three Ways Better . . .

International Nickel Company of Canada expects USS "T-1" Steel to increase the service life, to reduce the maintenance, and lower the long-term cost of ore cars like this one; because "T-1" Steel has far greater strength, toughness, and resistance to abrasion than steel used previously. The car builder, Canadian Car and Foundry Co., Ltd., has had no difficulty fabricating this very strong alloy steel.

HOW USS "T-1" STEEL CAN HELP YOU

The great strength and toughness of USS "T-1" Steel (90,000 psi. minimum yield strength) helps you to increase the capacity and durability of power-shovel buckets and storage tanks without increasing weight.

Its excellent weldability enables you to fabricate large equipment out in the field without heat treatment. It thus reduces fabricating and shipping costs and speeds up construction.

Its unusual toughness at sub-zero temperatures improves service life of equipment that must take impact, abrasion, and abuse in all weather.

USS "T-1" Steel also gives you good creep-rupture strength to 900°F. It often can be substituted for more expensive steels that are more difficult to fabricate. There is a place for "T-1" Steel somewhere in your designs. Write, wire, or phone for complete information. United States Steel, Room 5310, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

XV

This is the fifteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Boron and Its Effects in Alloy Steels

Boron is a nonmetallic element of which this country has a plentiful supply. In its natural or unprocessed state it occurs only in combination, as in borax, etc. Pure boron is a gray, extremely hard solid with a melting point in excess of 4000 deg F.

This element is used in steel for one purpose only—to increase hardenability; that is, to increase the depth to which the steel will harden when quenched. Its effective use is limited to sections whose size and shape permit of liquid quenching. Only a few thousandths of 1 pct is ordinarily added, and boron steels are evaluated by increased hardenability rather than chemical content. A number of alloys, including several grades of ferroboron, are available for adding boron to steel.

Boron intensifies the hardenability characteristics of other elements present in the steel. It makes possible a considerable degree of alloy conservation when used with steels containing small amounts of alloying elements. However, since it readily oxidizes at high temperatures, some steelmakers prefer a melt with relatively low boron content and relatively high contents of other elements that protect the boron from oxidation.

It should be noted that boron is very effective when used with low-carbon alloy steels; but its effect is reduced as the carbon increases. When the carbon content is above 0.60 pct, the use of boron is not suggested, the exception being the "case" in those steels that are carburized.

Boron steels often require closer temperature control in heat-treatment than do some of the other alloy analyses; but aside from this they present no special problems. Their cold- and hot-working properties are considered at least equal to those of ordinary alloy steels. In cases where boron makes possible a lower alloy content, improved machinability frequently results.

If you would like to know more about boron and its effects in alloy steels, you are invited to consult with Bethlehem's metallurgical staff. Our technicians will gladly give you all the information you need, and will work closely with you in every respect. And when it is time to replenish supplies of steel, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

If you would like a reprint of this advertisement, or of the entire series from I through XV, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

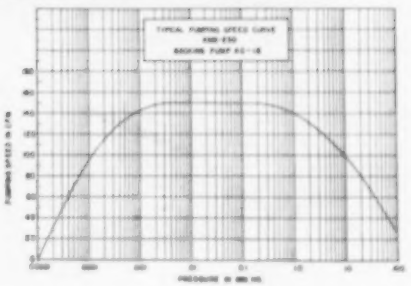
BETHLEHEM STEEL

BEGORRY! WE'VE BEGAT AGAIN!!

There's an addition to KINNEY'S MECHANICAL BOOSTER VACUUM PUMP FAMILY... the new Model KMB-230!

FOR VACUUM MELTING, the design and ultimate production of the Model KMB-230 was a natural. It provides a 230 CFM pump for those vacuum metallurgy installations where the Kinney workhorse (the Model KMB-1200) was too large. Of similar design (the KMB-230 is combined with a Model KC-18 for roughing out purposes), it offers the same dependable, trouble-free service . . . the highest volumetric efficiency, and highest dollar return per CFM available in any high vacuum pumping system.

FOR YOUR METALLURGICAL VACUUM PROCESSING SYSTEM, investigate the outstanding performance records of these Kinney pumps. We will be glad to provide you with any vacuum data you need . . . to make your operation more economical. Contact any of our competently staffed district offices . . . in Baltimore, Chicago (La Grange), Cleveland, Detroit, Houston, Los Angeles, New Orleans, New York, Philadelphia, San Francisco, or St. Louis . . . or mail coupon today for additional information. Take time to make one of your smartest moves. Kinney Mfg. Division, Boston 30, Massachusetts.



SPECIFICATION DATA

Model KMB-230 Two Stage Mechanical Booster Vacuum Pump

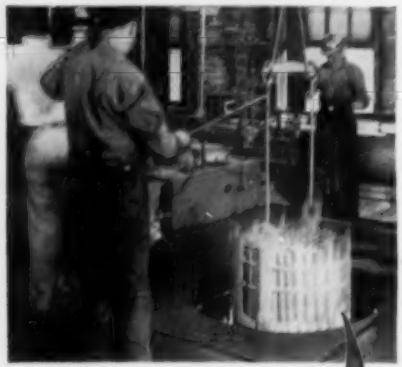
Ultimate Pressure (McLeod Gauge)	0.1 Micron
Free Air Displacement	230 CFM
RPM	3600/640
Motor H.P.	2 and 1
Oil Capacity	5 Pints
Cooling	Water
Shaft Seal	Mechanical
Shaft Diameter	¾/¾
Inlet Connection	4" Flanged
Outlet Connection	1¼" Screwed
Net Weight, Complete	1010 lbs.

write today

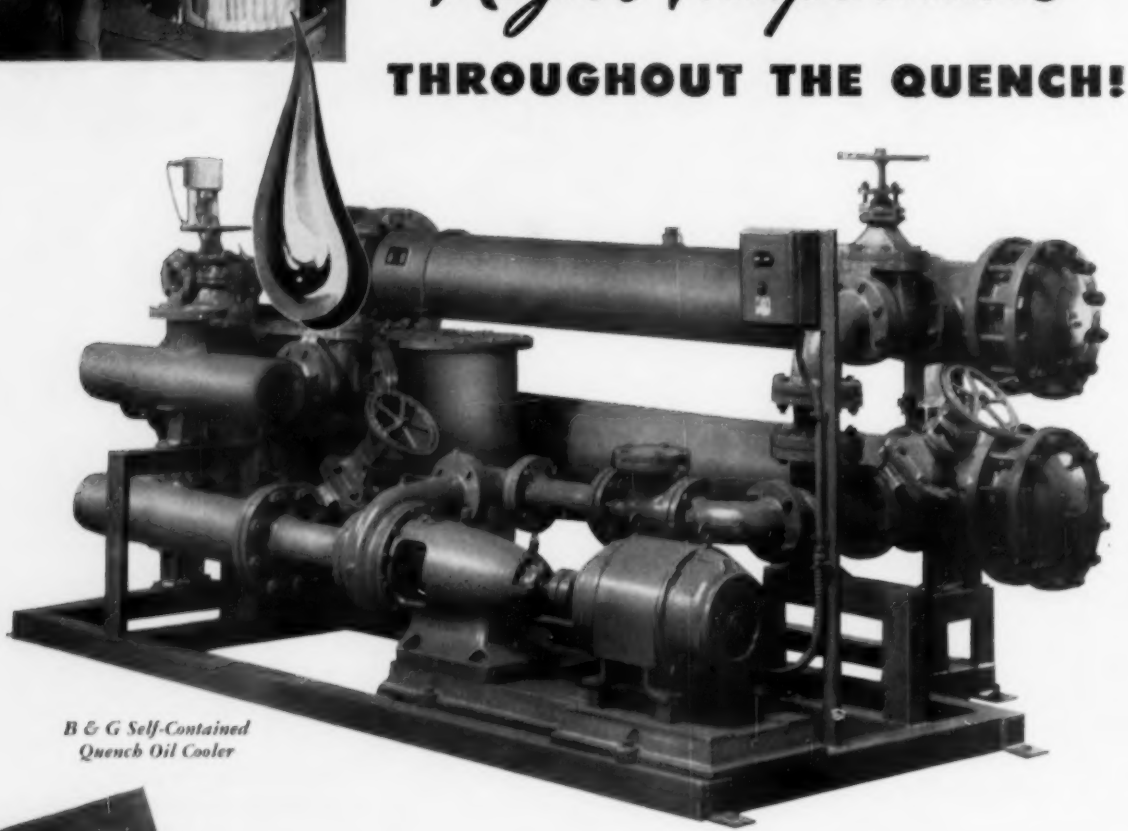
KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3504 WASHINGTON STREET • BOSTON 30 • MASS.
INTERNATIONAL SALES OFFICE, 50 WEST ST., NEW YORK 6, N.Y.

- Please send Catalog No. 425 describing the complete line of Kinney Vacuum Pumps.
  Our vacuum problem involves _____

Name _____
Company _____
Street _____
City _____ State _____



EVERY DROP OF OIL AT THE *Right Temperature* THROUGHOUT THE QUENCH!



B & G Self-Contained Quench Oil Cooler

This combined Catalog and Selection Manual gives full information.

Old-fashioned, uncontrolled quenching methods may be costing you more than you realize. By installing a B & G *Hydro-Flo* Quench Oil Cooling System you can eliminate losses caused by excessive rejects—make an "inside profit" by cutting operating costs.

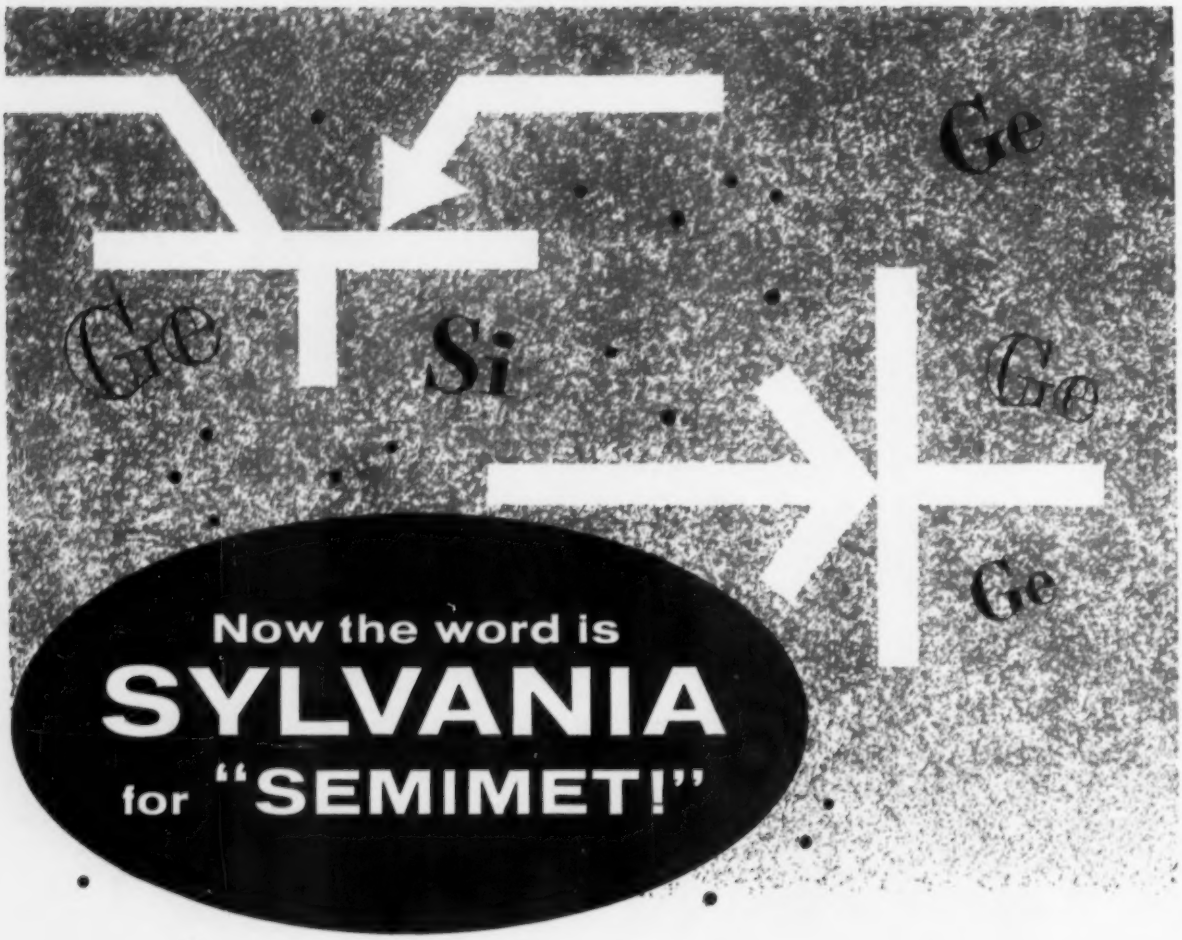
The "SC" Series *Hydro-Flo* Oil Cooler is completely self-contained—combining Cooler, Motor, Pump, Strainer and all controls in a single, integrated unit. Fully automatic, it keeps oil temperature at the desired degree through all stages of the quench.

Or, if you prefer, the component parts of a *Hydro-Flo* Oil Cooling System may be purchased and assembled on the job. In either case, you are assured of *uniform quality* in your product because of *uniform quenching conditions.*

Send for Catalog and Simplified Selection Manual.

BELL & GOSSETT
COMPANY
Dept. EI-16, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong Ltd., 1400 O'Connor Drive, Toronto, Canada



Ge

Si

...your single source for both transistor-grade silicon and germanium

Sylvania has long been a primary refiner of high-purity germanium. Now, newly completed facilities for the production of high purity silicon are operating on a pilot plant basis, producing the semimetal in needle or densified form, of spectrographic purity. Full production is expected in the spring. At present, transistor-grade samples are available for your testing on a letterhead request basis.

Specifications for Sylvania germanium dioxide and semimetal include ingot as-reduced (guaranteed 5 ohm cm resistivity) and polycrystalline ingot (guaranteed minimum 30 ohm cm resistivity). Whichever grade you prefer, you can be sure of continuing high quality and uniformity when you order from Sylvania.

If you use semimetals in your products . . . or plan to in the future . . . write for technical specifications and quotations on Sylvania silicon and germanium. Remember, too, that our engineering staff is always ready to help you solve semimetal application problems.

SYLVANIA ELECTRIC PRODUCTS INC.
1740 Broadway, New York 19, N. Y.
In Canada: Sylvania Electric (Canada) Ltd., University Tower Bldg., St. Catherine St., Montreal, P. Q.

SYLVANIA®

LIGHTING • RADIO • ELECTRONICS • TELEVISION • ATOMIC ENERGY

making stainless steel?

WASTE IS COSTLY!

Waste can mean a lot, especially if you have excessive conditioning costs or high rejection rate.

The addition of Vancoram Grainal Alloys has greatly improved hot-working characteristics of stainless and heat-resisting grades for many producers.

Think what that means—particularly in the higher alloy grades that are prone to develop cracks and other surface defects. Grinding, chipping and scarfing—the loss of good metal can be held to a minimum. You save in rejection and conditioning costs, which result in higher yield and the conservation of scarce alloying elements. And you step up production at the same time.

Why not try this new application of Vancoram Grainal Alloys. Your nearest Vanadium Corporation Sales Office will be glad to help you.

VANCORAM

Producers of alloys, metals and chemicals

VANADIUM CORPORATION OF AMERICA

420 Lexington Avenue, New York 17, N. Y.
Pittsburgh · Chicago · Cleveland · Detroit

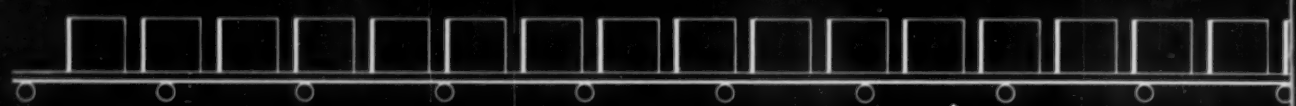
WHICH PRODUCTION PATTERN IS YOURS?

JOB LOTS—VARIETY OF SMALL PARTS

JOB LOTS—VARIETY OF LARGE PARTS

HIGH PRODUCTION—SAME SMALL PARTS

HIGH PRODUCTION—SAME LARGER PARTS



NOW . . . 4 NEW G-E INDUCTION HEATERS MATCH

You get maximum induction heater performance at minimum investment cost when you choose one of General Electric's new electronic induction heater models. Each model is tailored to one of the basic production patterns illustrated above. This lets you buy only the induction heating features you need for your particular production pattern.

In any one of the four ratings—7½-, 15-, 25-, 40-kw—you can choose a model to match your production pattern:

FOR HEATING SMALL AREAS the built-in output transformer is recommended. This feature enables you to couple power at maximum efficiency into a wide variety of low-impedance inductor coils.

FOR HEATING LARGER AREAS the tapped tank coil is recommended. The tap-adjustment feature lets you couple the heater power into a wide variety of high-impedance inductor coils.

FOR JOB-LOT PRODUCTION OF A WIDE VARIETY OF PARTS, variable power adjustment is recommended. Grid control of thyratron tubes permits manual adjustment of power under load from 0 to 100 per cent.

FOR HIGH-VOLUME PRODUCTION, IN WHICH YOU DO NOT HAVE RAPID CYCLING, the variable power adjustment feature is not needed. In these applications, the heater is adjusted initially to heat a specific part. No further adjustment is necessary until you change to a different part.

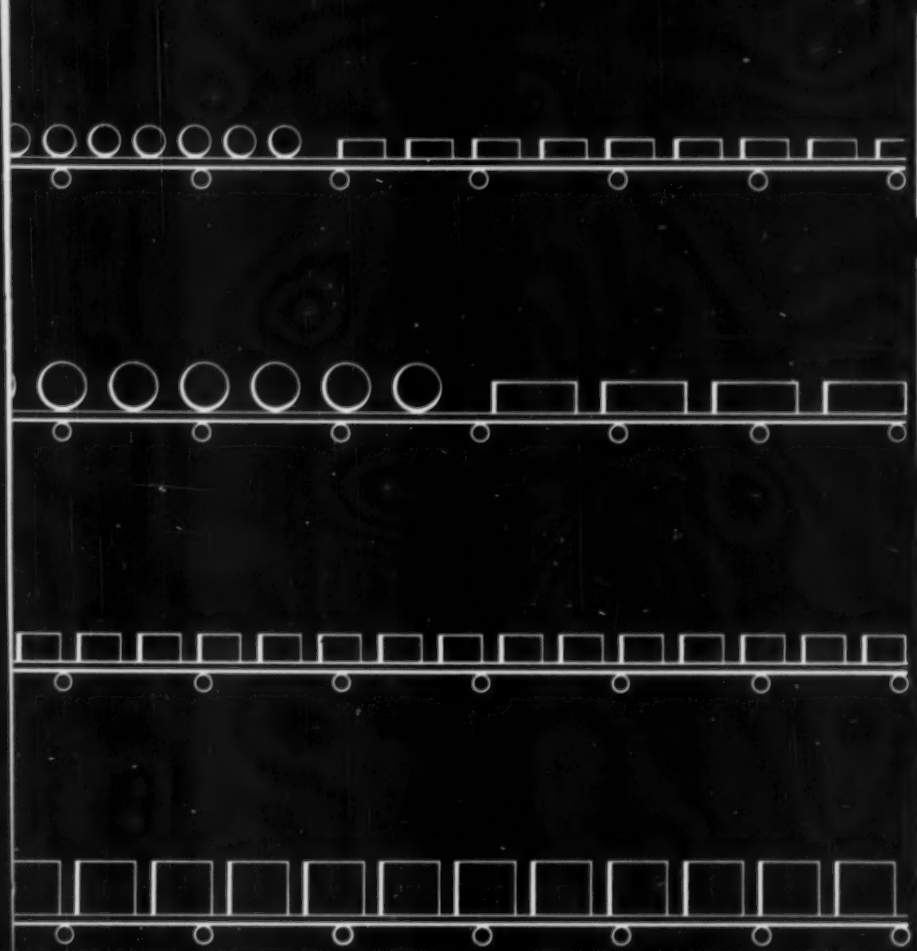
Features in any of the four ratings can be combined in the following fashion:

Model	Thyratron	Output Transformer	Tapped Tank Coil
4HM L1	x	x	
4HM L2		x	
4HM L3	x		x
4HM L4			x

Your nearby G-E Heating Specialist will help you choose the model best suited to your production pattern. You'll be paying only for those induction heater features you will use in your operation.

For specific bulletin information about these new induction heaters send in the coupon at the right.

GENERAL ELECTRIC



4HM L1

4HM L3

4HM L2

4HM L4

ANY PRODUCTION PATTERN . . . ECONOMICALLY

G.E. Gives You All These Features — and More!

DESIGN FEATURES	G.E.
High KVA Oscillator	
Built-in Water-to-air Heat Exchanger	
Readily Accessible for Maintenance	
Four Models in Each Rating	
Totally enclosed Aluminum Oscillator Box	
Dust-tight Cabinet Construction	
Industrial-type Oscillator Tubes	
Filament Voltage Regulation of ±3%	
Water Flow Switch to Protect Oscillator Tube	
Three Instruments on Control Panel	

FREE BULLETIN
Section C722-4
General Electric Company
Schenectady 5, New York

Please send me a copy of your bulletin "New G-E Electronic Induction Heaters" GEA-6388.

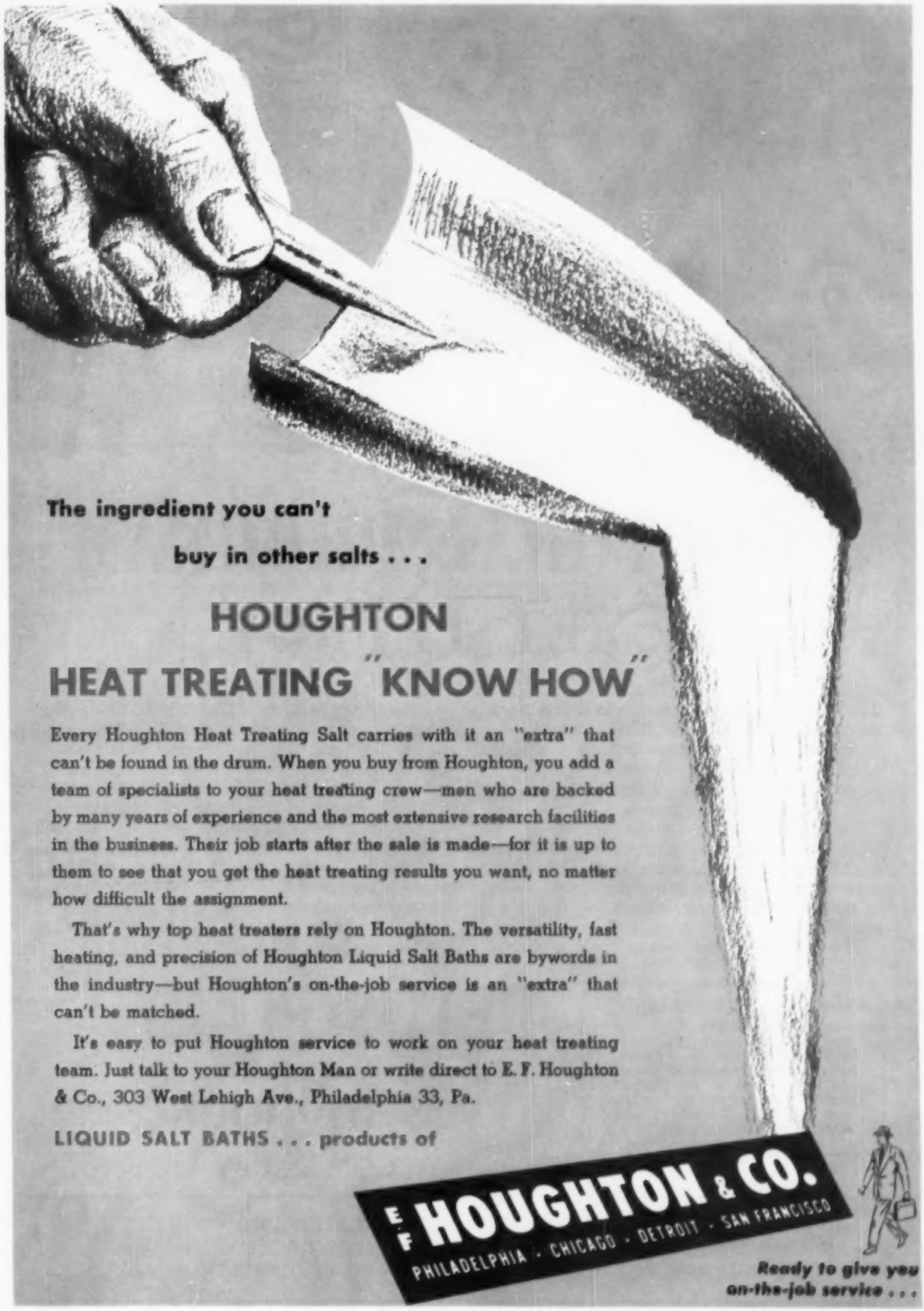
Name .....

Company .....

Street .....

City ..... **State** .....

GENERAL ELECTRIC



The ingredient you can't buy in other salts . . .

HOUGHTON HEAT TREATING "KNOW HOW"

Every Houghton Heat Treating Salt carries with it an "extra" that can't be found in the drum. When you buy from Houghton, you add a team of specialists to your heat treating crew—men who are backed by many years of experience and the most extensive research facilities in the business. Their job starts after the sale is made—for it is up to them to see that you get the heat treating results you want, no matter how difficult the assignment.

That's why top heat treaters rely on Houghton. The versatility, fast heating, and precision of Houghton Liquid Salt Baths are bywords in the industry—but Houghton's on-the-job service is an "extra" that can't be matched.

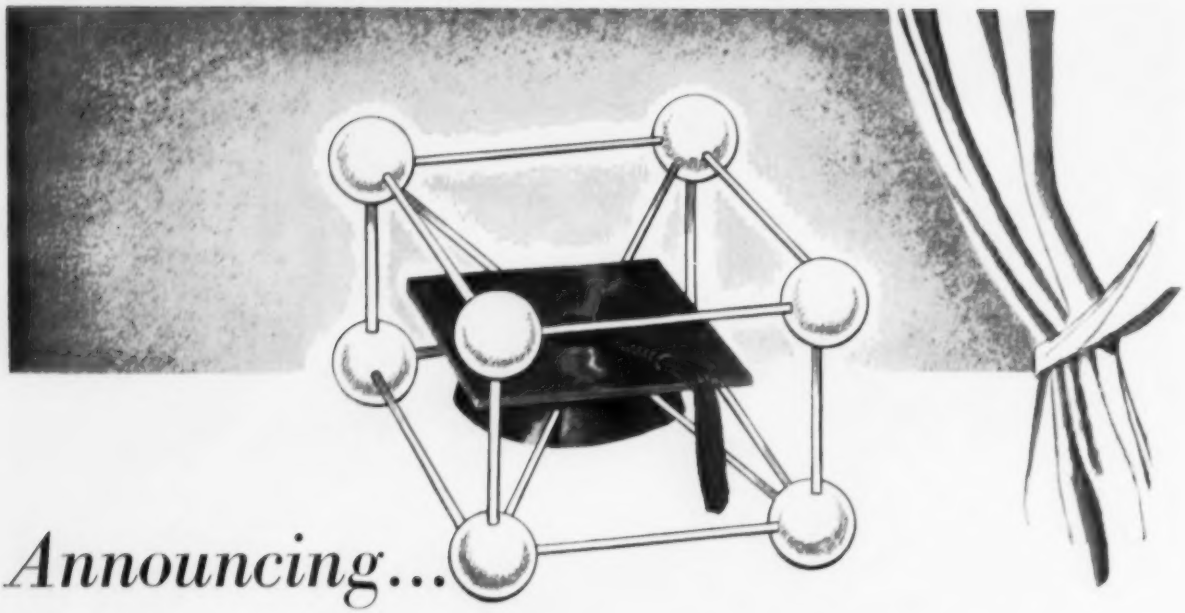
It's easy to put Houghton service to work on your heat treating team. Just talk to your Houghton Man or write direct to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

LIQUID SALT BATHS . . . products of

E F HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



Announcing...

a DOCTORAL PROGRAM in METALLURGY

The need for highly trained metallurgists in the nuclear field is urgent. That is why Westinghouse Electric Corporation and Carnegie Institute of Technology have inaugurated a Doctoral Program in metallurgy for promising young engineers and scientists.

This unique program is planned so that a recent college graduate may earn his doctoral degree in five years. The curriculum is flexible; students who have received degrees in fields of science other than metallurgy can also participate.

Those selected will pursue their graduate studies on the campus of Carnegie Institute of Technology while working only 32 hours—at full 40 hour per week pay—with Bettis Plant metallurgists who have pioneered in nuclear power. An unusual aspect of the program is the financial support that permits full time study on the campus during the fifth year.

If you are a recent college graduate in engineering or science with an outstanding academic record, a U.S. citizen interested in advanced degree study in metallurgy, write today for a descriptive brochure and an application for this program.

DEGREE REQUIREMENTS

Applicants must have at least a Bachelor of Science degree in one of these fields: metallurgy, physics, chemistry, chemical engineering, mechanics or mechanical engineering—earned within the past four years exclusive of time spent in military service.

BETTIS PLANT
Westinghouse

FIRST IN ATOMIC POWER

FIRST CLASS STARTS FALL SEMESTER 1956

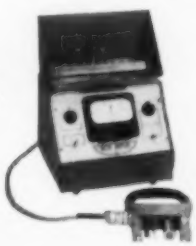
WRITE: DIRECTOR, EDUCATION AND TRAINING GROUP
WESTINGHOUSE BETTIS PLANT, P. O. BOX 1468, PITTSBURGH 30, PA.

You can't afford "mistaken identity" on your production line!

It's hard to believe that the wrong metals get into production so often, and even worse, into finished products. Yet the causes of such mistakes are usually very simple.

Errors are made in shipping or metal stocks are mis-identified. Errors occur in processing, too. Accidental mixing of hardened and unhardened parts of similar appearance is common.

No matter how sly their origin, these undetected situations inevitably get out of hand and into cost figures. Tools are damaged; production time is lost. Parts pile up in scrap, or worse, get by inspection and fail in the hands of the customer.



How Brush METAL MONITOR takes the guesswork out of metal identification.

Most plants are surprisingly susceptible to these cases of "mistaken identity" which cost millions of dollars every year. *But now these wastes can be eliminated!*

New Shop Tool Identifies Metals

Brush Electronics offers a new instrument, the Brush METAL MONITOR, which will detect variations from approved metal specifications at any stage of processing. It works on ferrous or non-ferrous metal, is nondestructive, won't mar finished surfaces. And it's portable, easy to use. Any worker can check any metal anywhere in the shop. The METAL MONITOR prevents losses due to the use of the wrong metals.

How It Works

Metal checks are easy to conduct. The METAL MONITOR probe is held momentarily on a sample of metal known to have the desired structure and composition and the operator obtains an immediate reading. He then holds the probe on the piece to be checked. If the reading is the same, the metal is the same . . . if the reading varies, it's the wrong metal.

Write for this introductory booklet on the new Brush METAL MONITOR now!

To get the complete facts about this fast, accurate instrument, send for your free copy of a brand-new booklet. It describes the Brush METAL MONITOR in detail, explains how it will save money for your company.

*T.M.

BRUSH ELECTRONICS COMPANY

3506 Perkins Avenue, Cleveland 14, Ohio

BRUSH 6 ELECTRONICS

DIVISION OF CLEVITE CORPORATION

76 MILLION welding rods through these **CROMOVAN** feed rolls!

36 months service and still going strong!

CROMOVAN, a Firth Sterling air hardening, high carbon–high chrome die steel is a terrific performer in wear and abrasion resistance applications.

For example, carbon steel feed rolls at Marquette Manufacturing Company, Minneapolis, lasted only seven months even when serviced constantly, but CROMOVAN replacements are still going strong after 36 months of grueling use and *no* servicing! Four feed rolls guide 14" welding rods (stainless, carbon, and alloy steel) into a flux coating machine at 700 ft. per minute and 76,000,000 rods passed through them with only .022" groove wear and *no down time* for redressing.

You, too, can realize comparable savings, reduced maintenance, and higher production when you adopt CROMOVAN for feed rolls, guides and wear parts. Write for Technical Bulletin 20-010 or 20-011 (Free Machining), today.

Mr. Tooley says—

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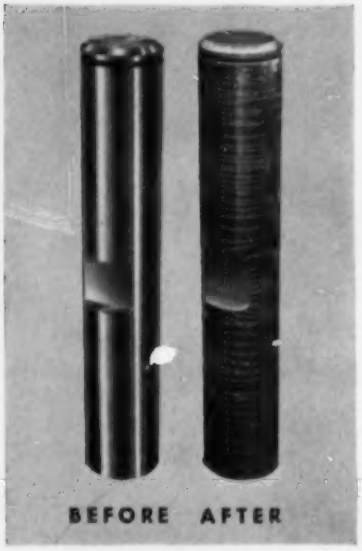
Case Studies: TESTING METHODS

Stresscoat is a Magnaflux developed brittle lacquer coating for testing and measuring stresses in working parts and designs. Stress analysis is providing new ways to reduce the cost and weight of products to make them stronger, better and cheaper.



Inspection with fluorescent Magnaglo under black light reveals cracks as glowing danger signals impossible to overlook. Magnaglo increases the speed of inspection and makes it easy to spot and identify defects in keyways, threads and other hard to see places.

"GOOD TURN" INSURANCE pays off for the Todd Shipyards Corp., Brooklyn, N. Y. A portable Magnaflux unit is used to inspect for cracks in keyed taper of an 18" propellor shaft of one of the giant ocean-going vessels.

Extra Savings in Both Manufacturing and Preventive Maintenance Inspection

Ⓜ methods pay "extra" dividends when used to inspect the products you make. These testing methods help pinpoint early defects in forgings, weldments, castings, bar steel and other component parts in the "rough" or finished state. It enables you to take corrective steps to eliminate their cause in the production process. You save the time, money and materials usually lost by processing defective parts and excessive scrap. By clearly showing the extent and seriousness of defects, Ⓜ methods provide added benefits from salvage operations.

A "safety" bonus can mean more than dollar savings in a preventive maintenance inspection program. Early detection of fatigue cracks in a crane hook can prevent an accident which could cost lives as well as money. Magnaflux offers many complete, easy, quick, portable methods for "in plant" or "in the field" inspection of machinery and equipment.

Consider for a moment, the many ways Ⓜ test methods can help you save "extra" in your present operations. Consult your Magnaflux engineer for specific information and examples of how Ⓜ can help you produce better for less!

"Conveyorized" Magnaflux inspection is engineered for jet engine production line. Jet engine vanes are inspected at the rate of 5,000 or more a day. First step is magnetizing vanes. Conveyor moves vanes into inspection booth (above) where inspector watches for any accumulation of magnetic particles indicating longitudinal defects. After passing through a second ferro-magnetic bath and longitudinal magnetic field, vanes are inspected for transverse defects. Then they move automatically through a de-magnetizer.

Write for complete details concerning any of the above case studies, (excerpts from MAGNAFACTS), or ask for our new booklet on Lower Manufacturing Costs.

Take Your Inspection Problems to the House of Answers . . .

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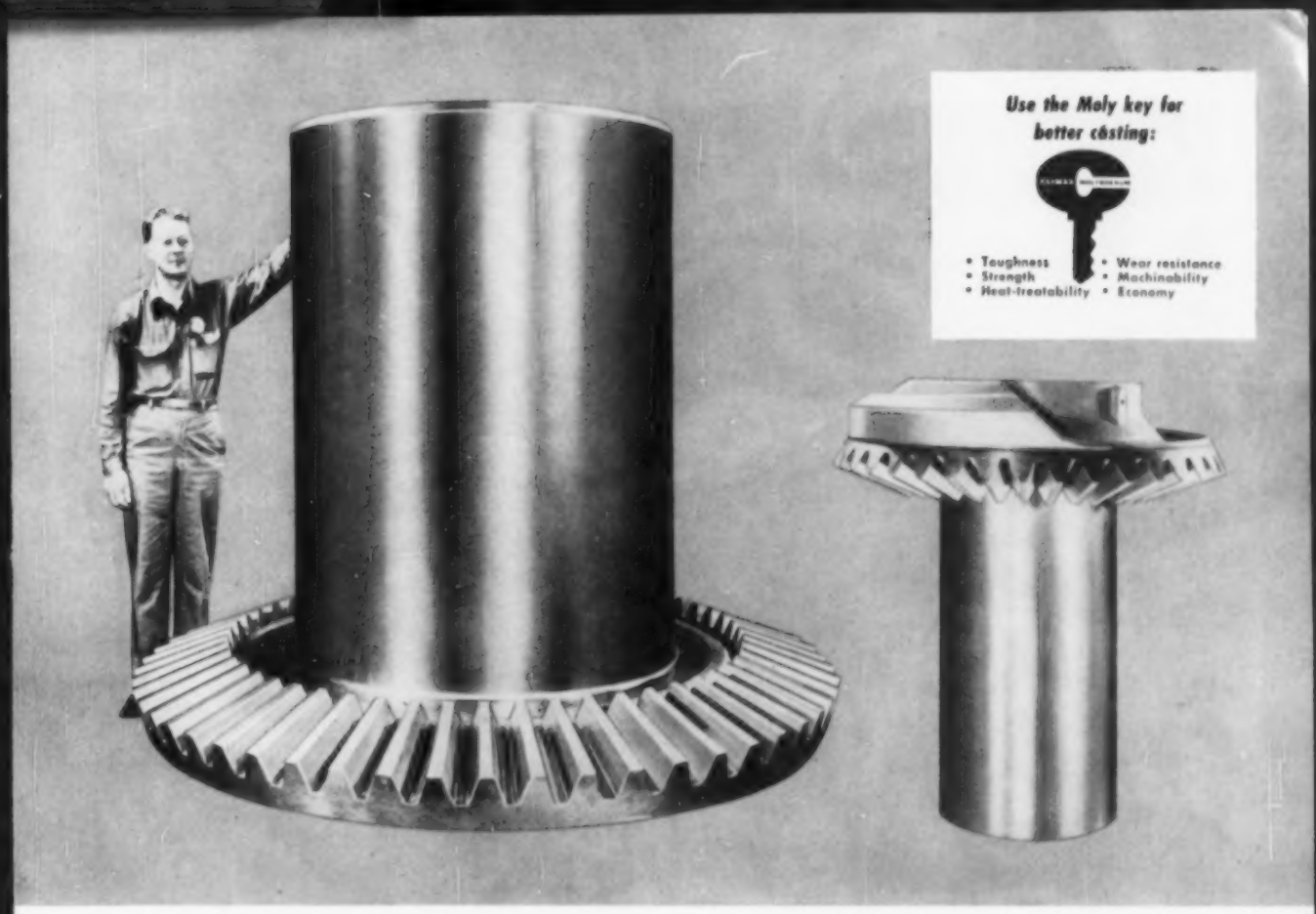
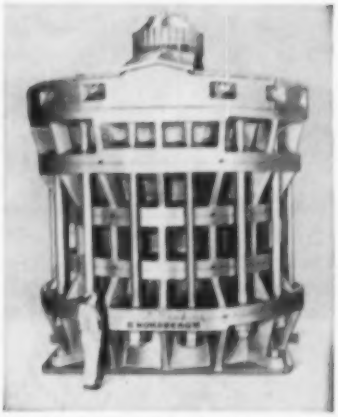


Heavy duty ore crushing machinery is subjected to severe operating conditions. To meet these strenuous requirements the gears shown are made from heat treated low-alloy manganese-*Molybdenum* steel castings. At left: a Symons Gyratory Crusher gear; right: a Symons Cone Crusher gear. Built by Nordberg Mfg. Co.

Cast Manganese Moly Steel contributes strength and toughness to Crushers built by Nordberg

"Where high strength and toughness are prime considerations," says Howard Zoerb, Consulting Engineer of the Nordberg Crusher Division, "molybdenum bearing steels are specified. This is true of the heavy duty parts of Symons® Crushers, built by Nordberg. These steels have contributed to the Nordberg reputation as producers of dependable, heavy duty crushing machinery."

Technical assistance is available to foundries on alloying problems. Please address inquiries on your foundry letterhead to: Climax Molybdenum Company, Department 5, 500 Fifth Avenue, New York 36, New York.



The Symons Cone Crusher is a product of Nordberg Manufacturing Company.

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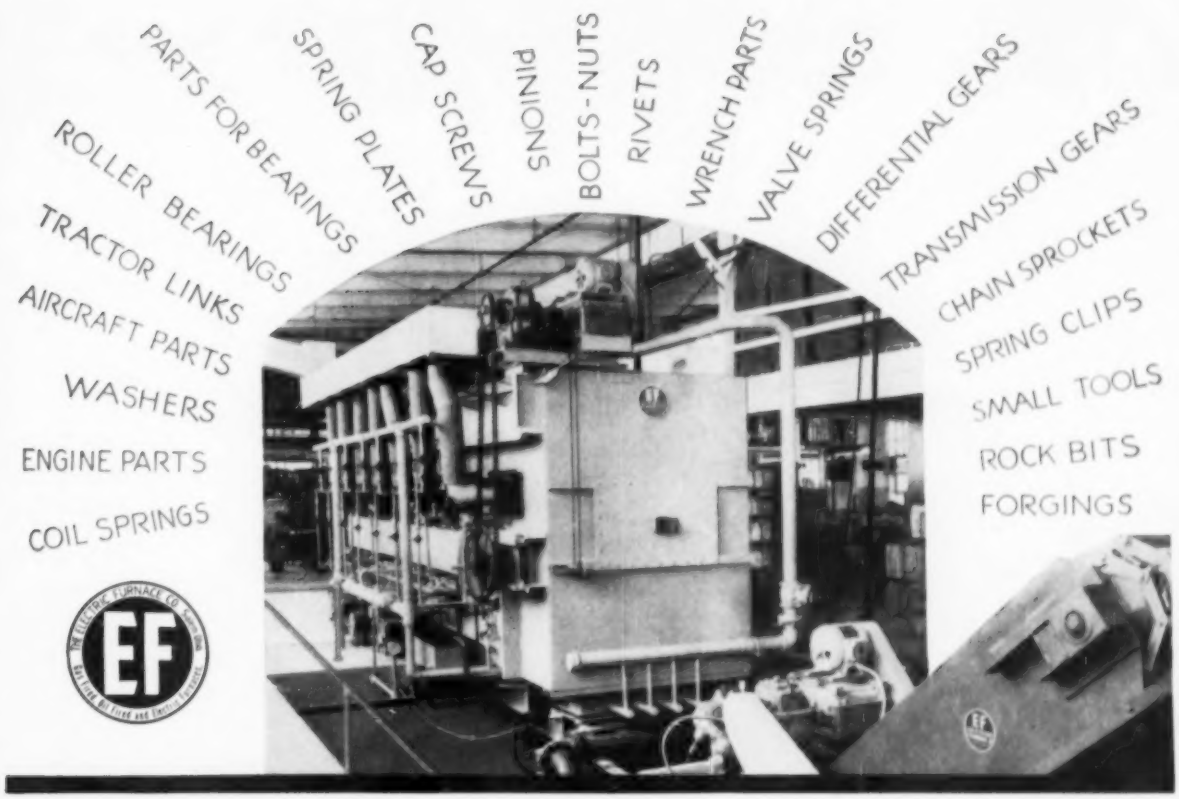

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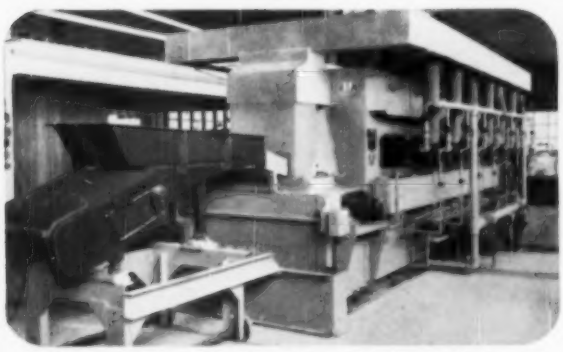

(Above) EF Gas Fired Radiant Tube Combination Hardening and Dry Cyaniding Unit Fitted with an Automatic Feeder that Distributes the Parts Evenly on the Chain Belt Conveyor; and a Dual Quench.

(View at top) The Conveyorized, Partitioned Dual Quench Moves Laterally to Permit either the Complete Oil or the Water Quenching Equipment to be Positioned under the Sealed Furnace Discharge.

• The EF chain belt conveyor furnace is one of the most satisfactory continuous heating units yet devised for scale-free hardening, carbon restoration, carbonitriding, carburizing and non-decarb heat treating small and medium size parts. The material is loaded onto our rugged heat resisting cast link conveyor belt; carried through the furnace; heated uniformly to proper temperature; automatically quenched and discharged. No pans or trays are needed. Hundreds in daily operation prove the dependability and efficiency of our design. 11 standard sizes. Capacities to 2000 lbs. or more per hour. Gas, oil or electrically heated. Furnished complete with any desired feeding, discharging or special atmosphere equipment. Write for folders describing our chain belt conveyor type and other production furnaces.

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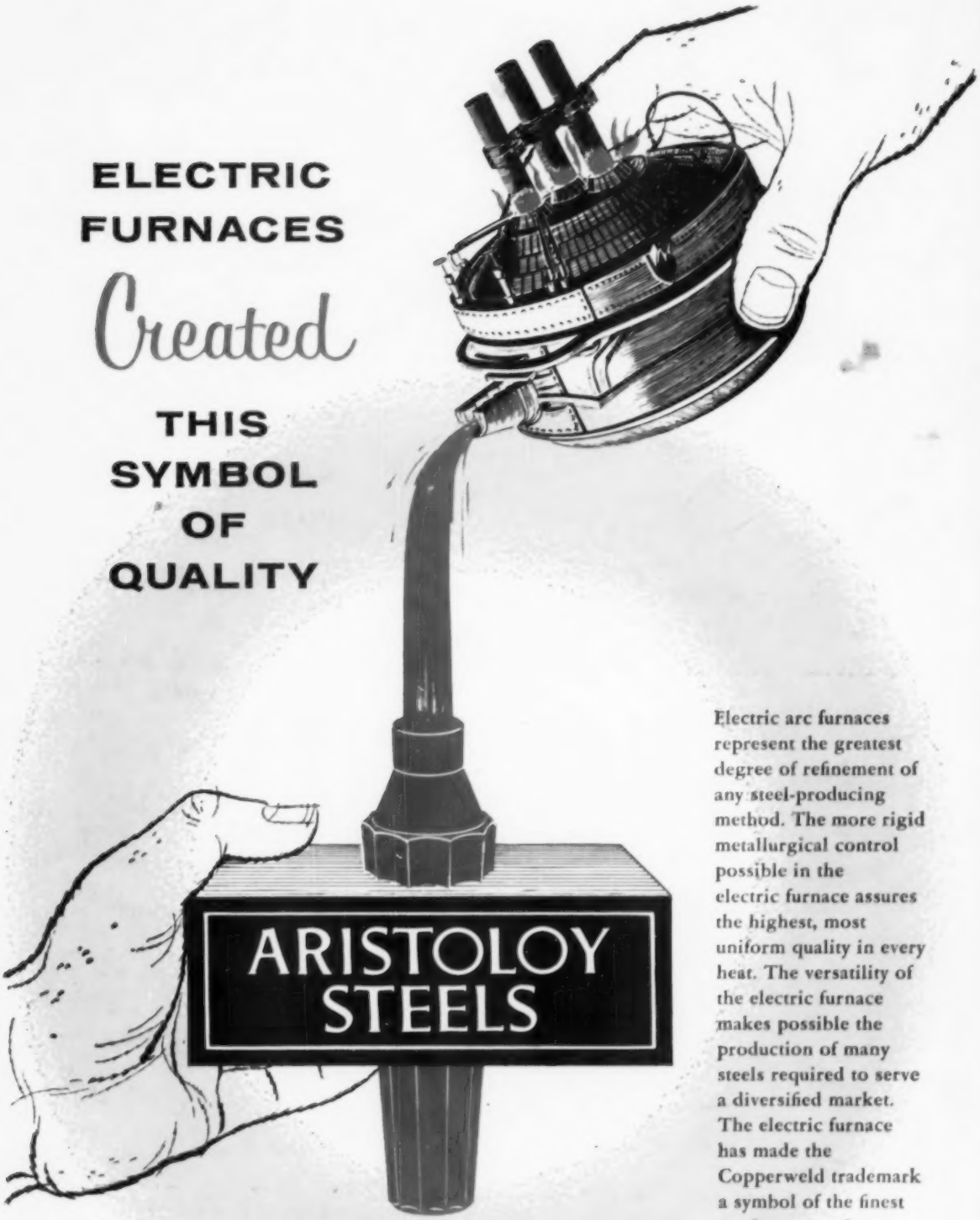

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